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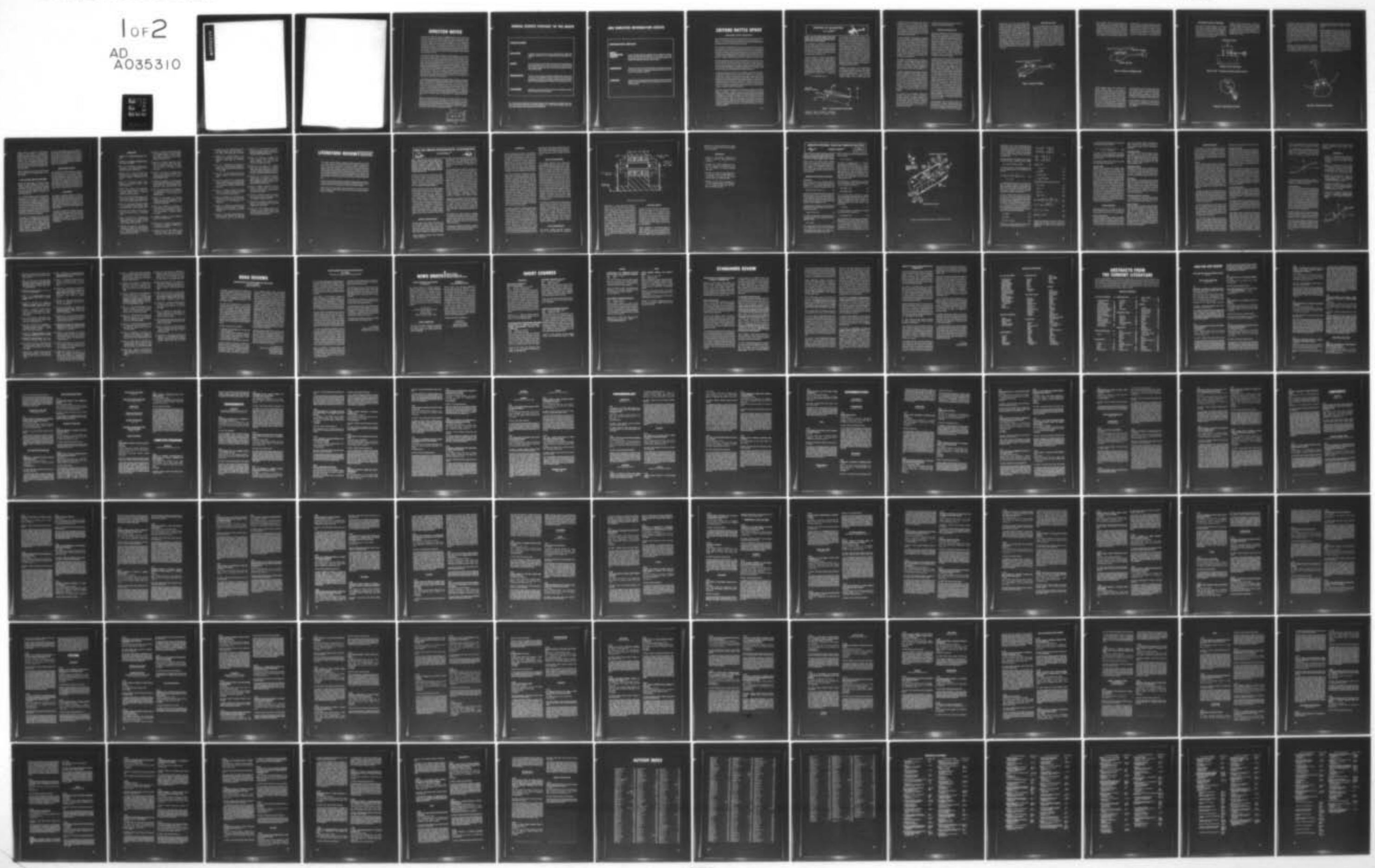

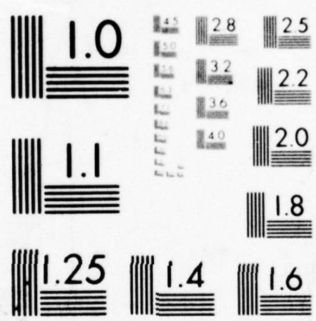

MICROCOPY RESOLUTION TEST CHART
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DIRECTOR NOTES

We are proud to begin our ninth year of **Digest** publication and our thirtieth year of service to the shock and vibration community. With the inauguration of President Carter this month, we will have served under seven Chief Executives. This is at least an indication that there is bipartisan agreement on the importance of technology transfer and communication of technical information. As President Kennedy said in 1963, "....strong science and technology is a national necessity and adequate communication is a prerequisite for strong science and technology." SVIC and other specialized information centers play an important role in effective communication, but we must not overlook the responsibilities of other segments of the technical community.

I feel that many authors these days assume too little responsibility for the links in the information transfer chain. In writing his paper, an author should concern himself more with the problems of dissemination and retrieval than he had to in the past. He can do this in three important ways. First, the title of a technical paper can be a very effective bibliographic device. This is only true, however, if the author selects a title that clearly and concisely conveys the sense of his paper. Second, the author can assume responsiblity for the selection of meaningful keywords. This will assist the information specialist in assigning keywords from his own thesaurus or provide the new words that are vital in the evaluation process required for an effective thesaurus. Finally, no one can abstract a paper as effectively and economically as the author. The editors of journals should encourage him to assume this responsibility. The author should also exercise judgement in his writing so as to contribute useful information to the literature.

In my opinion the unsung heroes of information transfer are those who undertake reviews. The preparation of a good review article is a task for those able to critically analyze, synthesize, and present essential information in a lucid manner. Their efforts serve not only the established workers in the field but also the general needs of the nonspecialist and the graduate student entering the field. Their work is a labor of love and dedication, for it is usually done on a voluntary basis. The technical community should somehow give increased recognition to outstanding review authors. At the same time the reviewer should realize that his responsibilities grow with the increasing complexity of technology and the expansion of the literature.

Progress is certainly being made, but, if each of us strives to play our role a little better, new information can be made easier to assimilate and easier to retrieve. The authors of books and papers, journal editors, and reviewers can all contribute significantly. We at the information center must continue to develop ways to make existing information available in useful form whenever and wherever it is needed. My hope is for another year of progress toward this goal.

H.C.P.

ANNUAL SERVICE PACKAGE* OF THE SHOCK

PUBLICATIONS

BULLETINS — a collection of technical papers offered at the SHOCK AND VIBRATION SYMPOSIA published once a year. *Catalog listing back issues available from SVIC.*

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AND VIBRATION INFORMATION CENTER

INFORMATION SERVICES

DIRECT INFORMATION SERVICE	the Center handles requests for information via mail, telephone, and direct contact. The Center technical specialists, who are experts in the shock and vibration field, have the SVIC computer implemented SHOCK AND VIBRATION INFORMATION BASE at their disposal.
WORKSHOPS	workshops on shock and vibration technology are organized and sponsored by the Center. Experts on specialized technology give lectures and write articles for the workshop proceedings.
SYMPOSIA	annual shock and vibration symposia bring together working scientists and engineers for formal presentations of their papers and for informal information exchanges.

EDITORS RATTLE SPACE

PUBLICATIONS: QUALITY AND QUANTITY

My recent editorials have been concerned with problems encountered in the publication of physical data and technical information. The goal of publication is -- or should be -- to inform and educate in a minimum amount of space. Many engineers and scientists today seem to have lost sight of this goal.

Many engineers and scientists belong to one of two groups. Within the first group are those who don't bother to know the literature. Those in the second group have reduced the scope of their problems to the point that they are worthless to anyone else. Instead of continuously publishing a new twist on an old problem or of dealing with meaningless phenomena, engineers should consolidate theory and data (see November 1976 editorial). It should be unthinkable that anyone would even try to publish material without having first conducted a literature search.

Because no standards for publication have been established, many technical publications are reworked. The same information may thus appear in several forms, none of which has much new technical content. A strong and uniform publication policy should be established by the technical societies, universities, industry, and the government. Their guidelines regarding material suitable for publication could serve as the beginning of a possible solution to repetitious literature.

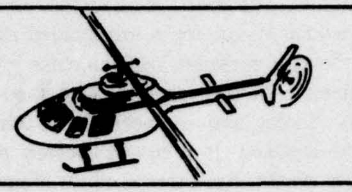
It might be argued that a new twist to an old problem does warrant publication. Unfortunately no guidelines exist on the content required of a "contribution" in order that it qualify for journal space, nor do space limitations exist. Most societies require only that contributions contain something "new." Many also stipulate that the information cannot have previously appeared in certain journals. No guidance is given on whether the "contribution" should be published as a full-length technical article or as a technical note. In my opinion much of the material I have in mind should be appearing as technical notes. Much of the background material now appearing could thus be eliminated.

What hope is there that these problems can be solved? It appears to me that one aspect of the problem -- expense -- is upon us. The ever higher costs involved in publishing and distributing magazines and journals are certainly going to necessitate a reevaluation of the quality and quantity of published material. The technical committees that exist within all societies will soon be forced by economics to become more aware of what is to be published -- and in what format. The work of these committees in drawing up useful policies and guidelines for publication will ease the burden reviewers now face in recommending specific "contributions" offered for publication and could serve to stimulate the formulation of uniform publication standards.

R.L.E.

VIBRATION OF HELICOPTERS

G.T.S DONE *



***Abstract** - This review describes helicopter airframe forced vibration excitation and response. Methods and hardware for vibration control including structural modification, isolation, absorbers, and rotor control are described.*

One characteristic of helicopters is that they are subject to severe vibration, as much as two or three times the level typically found in a fixed wing aircraft. Most of the literature pertaining to helicopter vibration has been concerned with vibration reduction. The role of vibration in helicopter dynamics has recently been summarized [1-3].

Excessive vibration can cause structural fatigue of helicopter components, damage to armaments and equipment on board the aircraft, passenger discomfort, and control difficulties for the crew. The major source of vibration, the main effects of which are evident in the fuselage, is the rotor. Continuous rotation of the rotor creates a periodic asymmetry of the geometric configuration of the helicopter. A simple analysis [1] shows that the thrust δT from a blade element δr wide and chord c in length (see Fig. 1) is

$$T = \tfrac{1}{2}\rho a c \delta r(U_T^2\theta - U_P U_T)$$

In the equation ρ is the ambient air density, a is the rate of change of lift coefficient with angle of incidence, θ is the angle between the blade element and the plane of the rotor disk, and U_P and U_T are the components of air velocity perpendicular and tangential to the axis of rotation of the blade. The thrust of the blade element is periodic to at least the third order in blade rotation angle because of the way in which θ, U_P, and U_T vary. For example, θ is affected by the cyclic pitch; this introduces a first order variation. U_T depends on the component of the flight velocity resolved in a direction normal to the blade and is also first order periodic. The perpendicular velocity component is affected by climb velocity, induced velocity, rotor disk tilt, and blade flap. The perpendicular velocity component can be shown to be at least second order periodic.

Integration of the thrusts δ T for all blades creates a net force/couple system that acts on the fuselage from the rotor. Some of the resultants are periodic in the blade passing frequency -- i.e., rotor speed expressed as the product of frequency and total number of blades -- and at possibly higher order

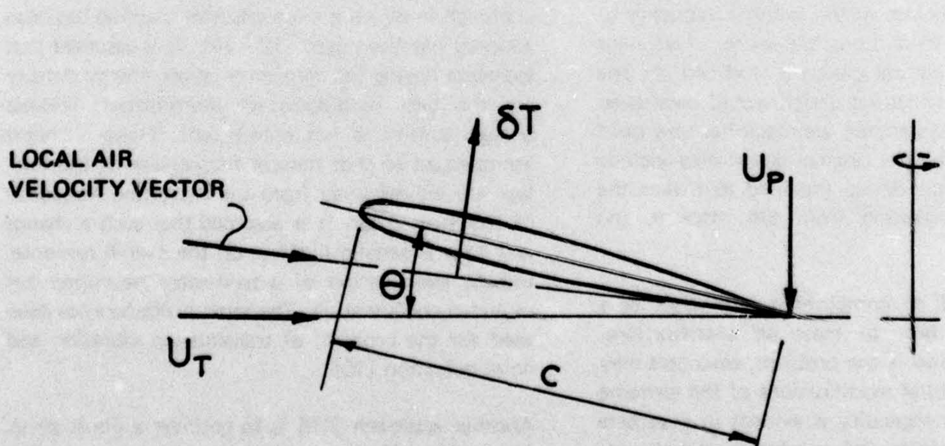


Figure 1. Thrust on Element of Rotor Blade

*Department Head, Department of Mechanical Engineering, University of Edinburgh, Scotland

harmonies. The thrust is oscillatory in this way for a two-bladed rotor; for a four-bladed rotor, however, the thrust is constant, and the rotor head moment is oscillatory. In this idealized case the resultant oscillatory forces and moments vary with the square of the airspeed. It is for this reason that the force/couple system has become more important as faster helicopters have been developed.

In practice, calculation of the variation of oscillatory forces and moments is complicated by the fact that harmonics other than those at a blade passing frequency appear. The vibration from the rotor may be supplemented by such blade effects as unbalance, faulty tracking, flexibility, reverse flow, and vortex interaction. Other vibration sources include the engine, gearbox and transmission, and tail rotor. These effects vary from one helicopter to another, so that vibration characteristics can differ widely, depending on the model, and even between two helicopters of the same model.

The subject of helicopter vibration sometimes includes such instability phenomena as ground and air resonance, pitch-lag instability, blade flutter, and tail rotor buzz and bang. This review is restricted to airframe forced vibration. General discussions on helicopter vibration have been published [4, 5].

Vibration is considered when a helicopter is designed. The best mathematical model available is used to determine whether or not the natural frequencies of the fuselage are close to the exciting frequency of the main rotor; if there is possible danger of resonant excitation, the structural design is modified. At one time, changes in structural design would have been intuitive; a more systematic approach has now been described [12-15]. The original design may include a vibration isolation device intended to reduce the transmission of vibration from the rotor to the fuselage.

The prototype of so complicated a product as a helicopter often fails to meet all specifications. If excessive vibration is the problem, absorbers may be added or structural modifications of the airframe may be necessary. Ingenuity is evident in absorbers used; technical reports and convincing claims concerning such devices usually do not stand up to detailed analysis, however.

A good block diagram of the sources of vibration and possible cures has been published [33].

STRUCTURAL MODIFICATION

Structural modification can usually involve any of a large number of components. In mathematical terms there are more variables than equations, so that the problem is an optimization problem. Optimization in the structural design of aircraft is a fairly recent development. Gellatly [6] has indicated the current situation. A good example of overcoming the complications of optimization of dynamic problems is available [7]; minimum weight structures of specified natural frequencies were used. Ellis [8] applied optimization techniques to helicopter dynamics: he used a simplex method to design engine support stiffnesses in order to minimize the forces transmitted from the rotor to the fuselage.

The theory of optimum structures [9] contains the following criterion: "The optimum structure is the one in which the average strain energy density (strain energy divided by mass) is the same in all its elements." This criterion actually applies only in the case of a static design for least weight. When a dynamic constraint is introduced -- such as a natural frequency -- the strain energy density can be replaced by the difference in the amplitudes of elastic strain and kinetic energy density in the specified response or normal mode [10, 11]. A strain energy density approach in which a more intuitive criterion has been adopted has been used [12 - 14]. It is assumed that elements having the maximum strain energy density are the best candidates for modification (kinetic energy density is not considered). These elements are changed so that natural frequencies of the fuselage are moved away from the excitation frequency of the main rotor. It is assumed that such a change will have a beneficial effect on the overall response; indeed, examination of a twin-rotor helicopter has provided confirmation. The same procedure has been used for the problem of transmission vibration and noise reduction [15].

Another approach [16] is to consider a linear structure subjected to constant forced excitation. The response at some point on the structure is examined as a function of various structural parameters -- such as the mass or stiffness of an element. The response

describes the arc of a circle in the complex plane. A small circle means that the parameter chosen does not have much effect on the response examined. The diameter of the circle is thus a measure of the effect of the parameter on response. This and other approaches have been used to indicate suitable areas for modification of a simplified single rotor fuselage model [17] and of a pilot's seat [18]. Areas predicted in the fuselage model compared favorably with modifications actually carried out. The method emphasizes the importance of the interface between the fuselage and gearbox (assumed to be mounted above the fuselage and below the rotor head), thereby confirming the potential value of vibration isolation in this area.

VIBRATION ISOLATION

On a conventional helicopter the fuselage is usually isolated from the gearbox, the engine, and the rotor head (see Fig. 2). Minimum transmissibility of force into the fuselage occurs if the suspension system (represented by the springs) is soft; that is, the natural frequency of the excited mass is much lower than the excitation frequency. Such a system is impractical, however, because continuous mechanical control across the interface is difficult and because maneuvering response is lost. Isolation systems are often designed to suit a particular helicopter model and to achieve only partial alleviation of transmitted vibration.

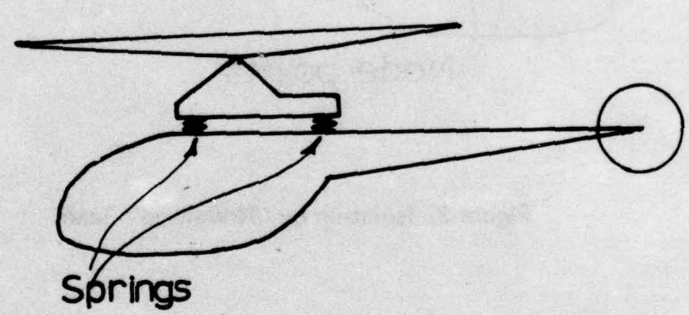


Figure 2. Isolation of Fuselage

Special isolation systems with general application have appeared; they are patented, however, and difficult to assess technically. One such device, called a nodalized beam, has been used on a flight test model of a well known helicopter [19]. The device is based on the principle that a flexible beam (which may carry a mass at its midpoint) has two nodes when vibrating in the fundamental free-free lateral normal mode. If the beam is supported at these nodes, no vibration is transmitted from the beam to the supports. The principle as it applies to the helicopter is shown in Figure 3. The model is a simplification of the actual situation, but effective isolation has been claimed; indeed, the comfortable and smooth ride is described as a "Noda-magic Ride."

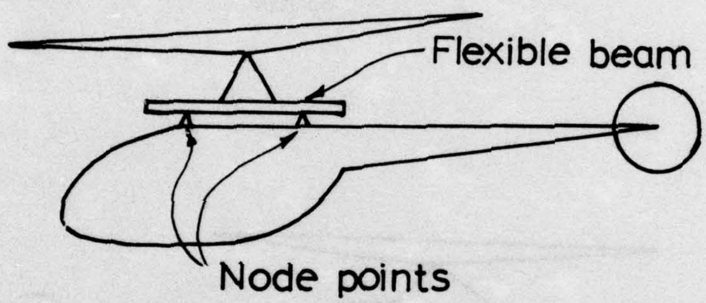


Figure 3. Isolation by "Nodalized" Beam

Another patented device is the "Dynamic Antiresonant Vibration Isolator," or DAVI [20]. A lever carrying a mass is connected across the interface between the excited mass and the isolated body (see Fig. 4). This system is based on the same principle as the nodalized beam: motion of the excited body is accompanied by a reverse motion of some part of the isolating system. The main advantage of the DAVI is that the suspension is stiff rather than soft. The transmitted force in the absence of damping is zero at a frequency somewhat higher than the natural frequency. When damping is present, the transmitted force is small and finite. DAVI devices could be fitted as part of the gearbox/engine/rotorhead suspension system. Both the DAVI and nodalized beam systems are capable of configuration changes while maintaining the original idea, and are thus capable of considerable further developments.

Another approach is to isolate the human occupants or cargo from the fuselage with a special seat or floor suspensions. But little information has appeared in the literature.

ROTOR-BORNE VIBRATION ABSORBERS

One popular and successful absorber is a rotor-borne device called a pendulum absorber (see Fig. 5). It is a mass mounted as a pendulum; the centrifugal force field of the rotor provides the stiffness or restoring force. The system is most effective if it is tuned so that the natural frequency equals the excitation frequency to be absorbed.

Consider the simple system shown in Figure 5(a), in which the pendulum swings in the plane of rotation. The natural circular frequency is $\Omega\sqrt{R/r}$; it is linearly related to the speed of rotation. The advantage of the system is that the absorber, after it has been tuned to a given frequency, remains in tune regardless of rotor speed.

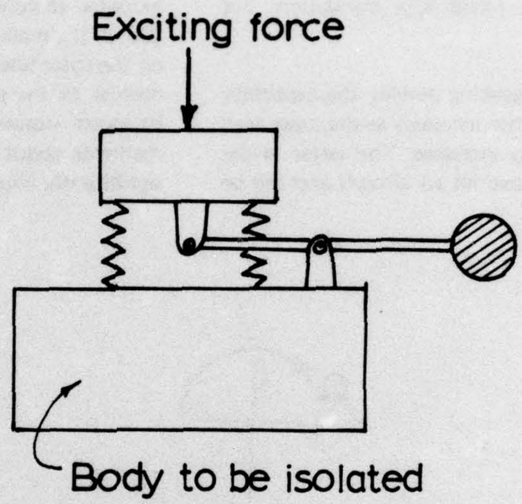


Figure 4. DAVI -- "Dynamic Anti-resonant Vibration Isolator"

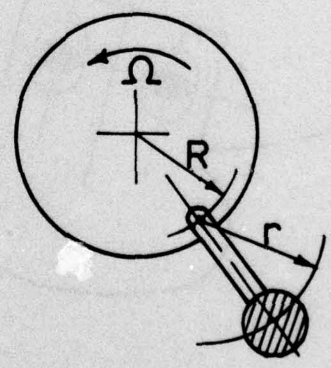


Figure 5(a). Simple Pendulum Absorber

The absorber is effective at high frequencies only if the ratio r/R is small, however. At high frequencies the bifilar pendulum shown in Figure 5(b) can be used. The pendulum mass is supported by two pins with a smaller diameter than the pins in the mass and the support. The pendulum mass rolls on the smaller pins. The radius of the small arc thus described is the difference between the diameters of the pins and the holes into which they are inserted. The radius of swing can be very small, but it should be noted that the displacement mode is a translation, not rotation.

Absorbers are force balancing devices; the capability of the pendulum absorber increases as the mass and/or amplitude of swing increases. The latter is the more desirable alternative on an aircraft and can be attained with sufficiently low damping; but the large amplitudes make the system nonlinear and affect tuning.

Pendulum absorbers were first used to reduce torsional oscillations in rotating machinery; see the theory of Crossley [21, 22] and Newland [23]. The bifilar pendulum has been used to suppress translational vibration in the plane of the rotor [24, 25]; each of a number of equally-spaced absorbers is mounted as shown in Figure 5(b). In another instance [26, 27] simple pendulum absorbers were mounted on the rotor blades; each absorber operated in a plane normal to the rotor disk. The absorbers effectively balanced vibrating forces normal to the disk and moments about axes in the disk. This resulted in a significantly improved vibration level.

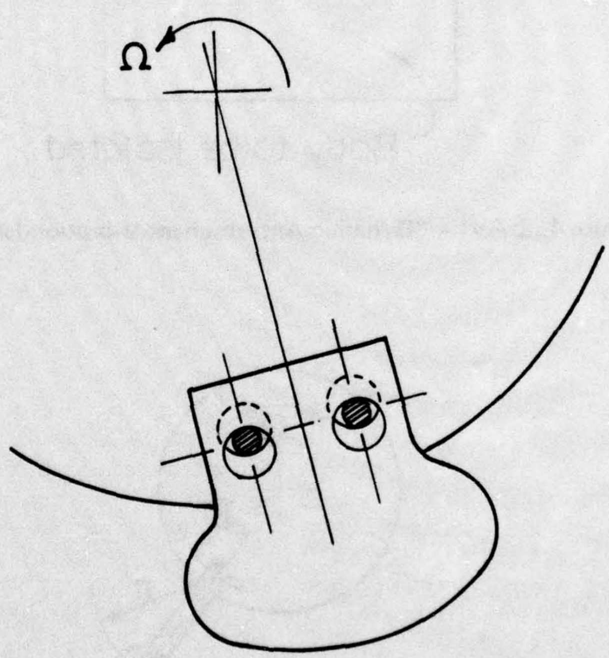


Figure 5(b). Bifilar Pendulum Absorber

Fuselage vibration is greatest at the blade passing frequency, or n/rev, where n is the number of blades. A blade with an oscillatory force at its root of (n-1)/rev can be shown to contribute to fuselage vibration at n/rev. The same is true for a force at (n+1)/rev. If both forces contribute significant vibration, both must be tackled; this has been done [26, 27]. Arner and Neff [26] used two sets of pendula; Weiss [27] used one set of pendula and a fixed tuning mass.

Pendulum absorbers have been shown [28] to bring about a reduction in the nonsteady case of transition vibration.

FUSELAGE-BORNE VIBRATION ABSORBERS

Because the angular speed of the rotor is almost constant at normal operating conditions, tuned vibration absorbers that are fixed in the fuselage are feasible. The fairly simple approach once used was to mount a spring mass at or near a point of excessive amplitude of vibration; the battery was often used as the mass.

In a more sophisticated approach that has recently been used [13, 14, 29, 30], the receptances (or mobilities as they are referred to in these papers) of the absorber and fuselage are used. Cross-receptances that connect forces and responses at the rotor hub with forces and responses at the absorber mounting positions are involved. The approach serves as an analytic tool, but the absorber mounting points and absorber parameters must be chosen on an engineering or intuitive basis; results of the analysis do not point to an optimum configuration.

The theory of anti-resonance [31] has allowed absorber position to be manipulated so that the optimum result can be achieved. A structure forced to vibrate adopts some mode of vibration that may have one or more modes. The anti-resonance theory allows determination of the relationship among forcing frequency, absorber position, and nodal position. The theory was also applied to selection of absorber position and to isolator design.

An unusual fixed absorber has been described [32]. The helicopter (for which an absorber was found to be most beneficial) was subjected to a rotor speed variation of six to seven percent under normal operating conditions. This large speed variation exceeded the limits of a normal tuned absorber. A tunable absorber that was automatically adjusted through a control system was designed.

DIRECT ROTOR CONTROL

An interesting way to alleviate vibration is to control the rotor blades so as to minimize the vibratory forces and moments on the rotor head. Vibration has been decreased by introducing periodic forces into conventional pitch controls via actuators [33]. The control input is calculated on the basis of measured forces and responses. A similar approach has been used [34]; the exception is that the basic control is jet-flap. Such systems are exploratory; the present state of research has been summarized [35].

CONCLUSIONS

The control of helicopter vibration has involved a wide variety of devices and methods. It is of interest that, apart from some basic ideas and inventions, the subject owes relatively little to the general field of vibration absorption, control, and isolation. On the other hand, there has been a correspondingly negligible transfer of information into the discipline of vibrations [36].

The dynamic response of the fuselage structure is a crucial factor in helicopter vibration, but published dynamic characteristics seem to be lacking. Normal modes represent a measurable summary of such characteristics, and White [37, 38] has provided theoretical and experimental examples for a full-size helicopter.

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LITERATURE REVIEW

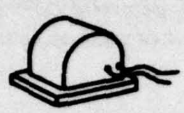
survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

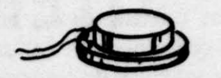
This issue of the DIGEST contains review articles on accelerometers and shock and vibration isolation oriented computer programs. Dr. William Mitchell of Harza Engineering reports recent developments in accelerometer design and usage.

Thomas Derby of Barry Wright Corporation describes commonly encountered shock and vibration problems and models for their solution. Available computer programs are described.

SHOCK AND VIBRATION INSTRUMENTATION: ACCELEROMETERS



W.S. MITCHELL*



***Abstract** - There have been few recent developments in accelerometer design and usage. Rather, changes have been concerned with refinement of transducer design, signal conditioning equipment, and acceleration measurement applications. Acceleration transducers are available for measuring almost any motion from near D.C. to 100 kHz. Temperature is still a limiting factor in certain measurement situations. Sensitivity, fidelity, and dependability are features of accelerometers now in use.*

During the past three years, no new dramatic breakthroughs have occurred in accelerometer instrumentation. Rather, available instrumentation has been refined: the number of types, sizes, frequencies, and amplitude ranges has increased, and reliability has improved. This article is an extension of an earlier article in the **Shock and Vibration Digest** [1].

Miniature accelerometers are now widely available. One manufacturer produces a series of piezoresistive devices ranging in weight from 0.5 to 2.5 grams. In a piezoresistive accelerometer the measurand is converted into a change in the resistance of a conductor or semiconductor by a change in mechanical stress. Resonance frequencies of these accelerometers range from 300 - 6,000 Hz; the dynamic range is ± 2,500 g. Another manufacturer supplies piezoelectric accelerometers with weights and frequencies to 2 grams and 90 kHz respectively. (In a piezoelectric accelerometer the measurand is converted into a change in electrostatic charge or voltage generated when certain materials are mechanically stressed.) Miniature accelerometers range from 0.004 to 0.02 in.^{3}.

GENERAL CHARACTERSTICS

Sensitivity varies widely among commercially available piezoelectric accelerometers: from less than 0.1 mV/m/s^2 (1 mV/g) to more than 100 mV/m/s^2 (1000 mV/g). Signal output is small; output impedance is high except for those transducers with amplifying circuitry. Operation of piezoresistive, bonded strain gage, and LVDT type accelerometers require an electrical input. They characteristically have a large signal and a low impedance. Transverse sensitivity is normally less than 5 percent of measurement axis sensitivity.

The functional frequency range of an accelerometer transducer depends on its type and manufacturer. Accelerometers can measure the frequency range from 0.01 Hz to 100 kHz; the actual range is limited by the resonant frequency of the accelerometer. The upper frequency limit may be as high as 40% of the accelerometer's resonant frequency. Another limiting factor is the measurement system, which includes cable, analyzers, meters, filters, recorders, and other signal conditioning equipment. If the measurement system, including the transducer, can be assembled so as to be capable of measuring acceleration amplitudes at very high frequencies, the final factor to be considered is calibration of the system. Although it is often overlooked in measurement procedures, calibration is necessary for the validation of data.

Accelerometers are available for measuring vibration acceleration amplitudes from 0.001 m/s^2 (0.0001 g) to 1×10^6 m/s^2 (1×10^5 g). The same transducers can typically withstand temperatures from -38°C to +260°C. The use of transducers at temperatures higher than 260°C usually requires a specially designed transducer or supplemental cooling with air or water.

Accelerometers are usually insensitive to magnetic fields. Because the transducer cable can be affected by dynamic strain, cable noise, and cable vibration, however, cable support and routing should be designed to prevent these effects from producing false measurement signals.

Accelerometer installations are generally sensitive to the phenomena of electrical ground loop when one side of the measurement system is grounded.

*Special Assignment Engineer, Harza Engineering Company, Chicago, IL

CALIBRATION

Among the few papers published in the past three years concerning the calibration of accelerometers is one describing developments since 1960 for small transducers of the type generally used for vibration and shock measurements [2]. Basic methods and advancements to 1974 for rectilinear steady state calibration are also described. The paper should be of particular interest to American users because the discussion includes steady-state methods and calibrators developed at the Australian National Standards Laboratory for absolute calibration by optical means.

A method for back-to-back calibration of accelerometers using a resonance type calibrator has been published [3]. The method applies to the problem of comparison calibration when both the test and reference accelerometers are assembled on the table of an electromagnetic vibrator. Significant error can result if the comparison is made at frequencies at which appreciable transverse motion of the vibrator occurs. Lateral motion is restrained with annular spring diaphragms that support the accelerometers and constrain their motion to a rectilinear path. The amplitude of the calibrating motion is amplified by driving the system at resonance. Many calibrating frequencies can be obtained by varying the thickness, material, and outer clamping diameter of the diaphragms. Accelerometer motion during calibration by this method has less than one percent total harmonic distortion and transverse acceleration for displacement up to 0.25 mm, peak-to-peak.

A transverse calibrator for calibrating accelerometers has been discussed [4]. With this calibrator a vertically mounted cantilever beam that vibrates in flexural motion is used. The test accelerometer is mounted on the top end of the beam; the sensitive axis of the accelerometer vertical. Two monitoring accelerometers are mounted orthogonally near the top of the beam, close to the test accelerometer. The cantilever beam is driven into motion in a horizontal direction, depending on the relative excitation of a pair of electrodynamic vibrator drivers. Vector summation of the monitoring accelerometer is used to determine the transverse sensitivity ratio (TSR) of the test accelerometer and the relationship between the TSR and the associated displacement angle. The data locate the least sensitive transverse axis of the accelerometer. Examples are given in the paper for a 100 Hz, 200 m/s^2 amplitude transverse calibration with the displacement angle increased at intervals of $10°$.

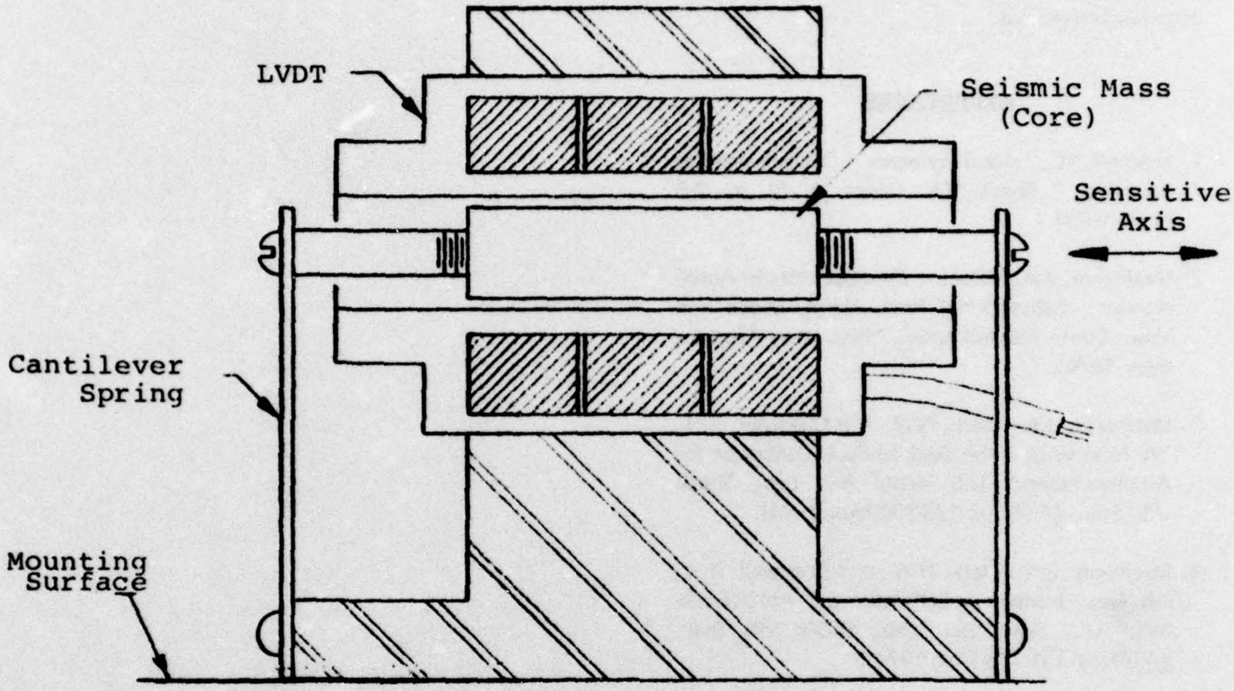
SERVO ACCELEROMETERS

D.C. operated, closed-loop servo accelerometers exhibit greater stability and accuracy than the open-loop type. Recent advances have allowed the manufacture of very small lightweight servo accelerometers. For example, one manufacturer advertises a one cubic inch servo accelerometer that weighs two ounces. Such devices can be used to measure tightly packed systems, in which the weight and size of the transducer are limited. Closed-loop servo accelerometers have replaced the older open-loop types in present-day applications. A source of error with the open-loop accelerometer is the mechanical spring part of the spring-mass sensing element system. This has been overcome with the closed-loop accelerometer by a more precise "electrical" spring that does not have the disadvantages usually associated with mechanical springs; namely, non-linearity, hysteresis, temperature sensitivity and fatigue effects. Other undesirable characteristics such as supply voltage sensitivity, acceleration (displacement) to voltage transduction, and zero shift are negligible in closed-loop accelerometers.

The linearity of closed-loop servo accelerometers is typically 0.05% of full scale; this is 20 times better than the percentage with most open-loop devices. Resolution and repeatability are approximately 0.0001% and 0.01% of full scale, respectively. Cross-axis sensitivity is about 0.005 gs/g. An unusual characteristic of closed-loop accelerometers is that neither natural frequency nor damping ratio are directly related to accelerometer range. Damping can be accomplished electrically. Natural frequency depends on feedback loop gain and the moment of inertia of the moving mass.

LVDT ACCELEROMETERS

The linearly variable differential transformer (LDVT) is often associated with displacement



LVDT Accelerometer

measurement. A typical accelerometer design is shown in the figure. The core of the LVDT acts as a seismic mass. The position of the core within the LVDT coils depends on a balance between the spring force and the applied acceleration. Because there is no feedback signal, the transducer is an open-loop accelerometer. The spring system that supports the seismic core and the LVDT coil windings is fixed to the body of the accelerometer case, which is mounted on a vibrating surface. When the case is accelerated, the displacement of the seismic core in the coil system is proportional to acceleration; the resulting voltage is proportional to the applied acceleration. The linearity of this transducer is typically better than one percent of full scale. Although the application of these accelerometers is somewhat limited, they are useful when accelerations are higher than 1,000 gs.

NEW DEVELOPMENTS

Accelerometers that have circular plate piezoelectric elements in compression and cylindrical elements in shear are well known. In a new design now being marketed three flat rectangular piezoelectric elements are mounted in shear around a triangular center post. According to the manufacturer the design produces a transducer that is less sensitive to external effects -- temperature change, magnetic fields, and base strain -- is more sensitive per unit weight, and has better amplitude linearity.

Another development in accelerometer design involves temperature. At one time accelerometers could be used at environmental termperatures up to 260°C. With special air or water cooling, they could be used on 980°C surfaces. Accelerometers are now

available that can function at 650°C without special cooling. This has been made possible with special materials and designs.

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COMPUTER PROGRAMS: SHOCK AND VIBRATION ISOLATION

THOMAS F. DERBY *

***Abstract** - The first part of this review describes commonly encountered shock and vibration isolation problems and the modeling and mathematical techniques used to solve them. The second part reviews available computer programs.*

Special purpose and general purpose computer programs are invaluable for the shock and vibration isolation analyst. Many good general purpose computer programs (e.g., NASTRAN, ANSYS, STA:-DYNE, MARC) that can solve shock and vibration problems are available; however, they are difficult to use and expensive.

RESPONSE OF RIGID MASS ON ISOLATORS

Linear Effects

The most commonly used analytical model for isolation analysis is a rigid mass supported by linear springs (Fig. 1). The equations that describe this system can be expressed in the general matrix form

$$[M]\,(\ddot{x}) + [C]\,(\dot{x}) + [K]\,(x) = (f) \tag{1}$$

Elements of the stiffness and damping matrices have been presented in terms of individual isolator and damping properties, orientations, and locations [1]. In some cases the rotational stiffnesses of individual isolators have been ignored [2]; the equations have also been written in algebraic form [3].

Undamped natural frequencies and mode shapes are determined by solving the equation of motion at zero damping and zero input:

$$[M]\,(\ddot{x}) + [K]\,(x) = (0) \tag{2}$$

The solution to equation (2) is a superposition of six sinusoidal functions, which represent the number of degrees of freedom.

$$(\ddot{x}) = -\omega_n^2\,(x) \tag{3}$$

The circular frequency of the n^{th} sinusoidal function is ω_n. Equations (2) and (3) can be combined as shown in equation (4), which is the eigenvalue problem to be solved.

$$[K]\,(x) = \omega_n^2\,[M]\,(x) \tag{4}$$

The solution -- six eigenvalues (ω_n^2, n = 1 to 6) and the corresponding eigenvectors, $[(x)_n$, n = 1 to 6$]$ -- describe the motion of the system when it vibrates with a frequency ω_n [4, 5]. The eignevalue problem can be solved with a subroutine such as General Electric SPEIGI [6]. Only the eigenvector can be determined. If the rigid body were displaced in translation and rotation according to a particular mode shape, the body would vibrate only at the natural frequency of that mode.

The eigenvectors (i.e., mode shapes) can be arranged to form a modal matrix, $[\phi]$. In the following equations from Crandall and McCalley [4]

$$[\phi]^t\,[M]\,[\phi] = [U] \tag{5}$$

$$[\phi]^t\,[K]\,[\phi] = [\Omega]^2 \tag{6}$$

$[U]$ is the identity matrix, and $[\Omega]^2$ is a diagonal matrix having ω_n^2 as the diagonal elements. A set of uncoupled coordinates (η), called the normal coordinates, are obtained from these equations. The relationship between the original and the normal coordinates is

$$(x) = [\phi]\,(\eta) \tag{7}$$

A required assumption concerning the damping matrix $[C]$ is shown in equation (8).

$$[\phi]^t\,[C]\,[\phi] = [D] \tag{8}$$

$[D]$ is a diagonal matrix with $2\zeta_n\omega_n$ as the diagonal elements; ζ_n is the fraction of critical damping in the n^{th} mode. If $[D]$ is proportional to $[M]$ or $[K]$ or a linear combination of the two, the left side of equation (8) will be a diagonal matrix. If $[C]$ is proportional to $[M]$, ζ_n is proportional to the reciprocal of ω_n; if $[C]$ is proportional to $[K]$, ζ_n is

*Staff Engineer, Barry Division, Barry Wright Corp., 700 Pleasant Street, Watertown, MA 02172

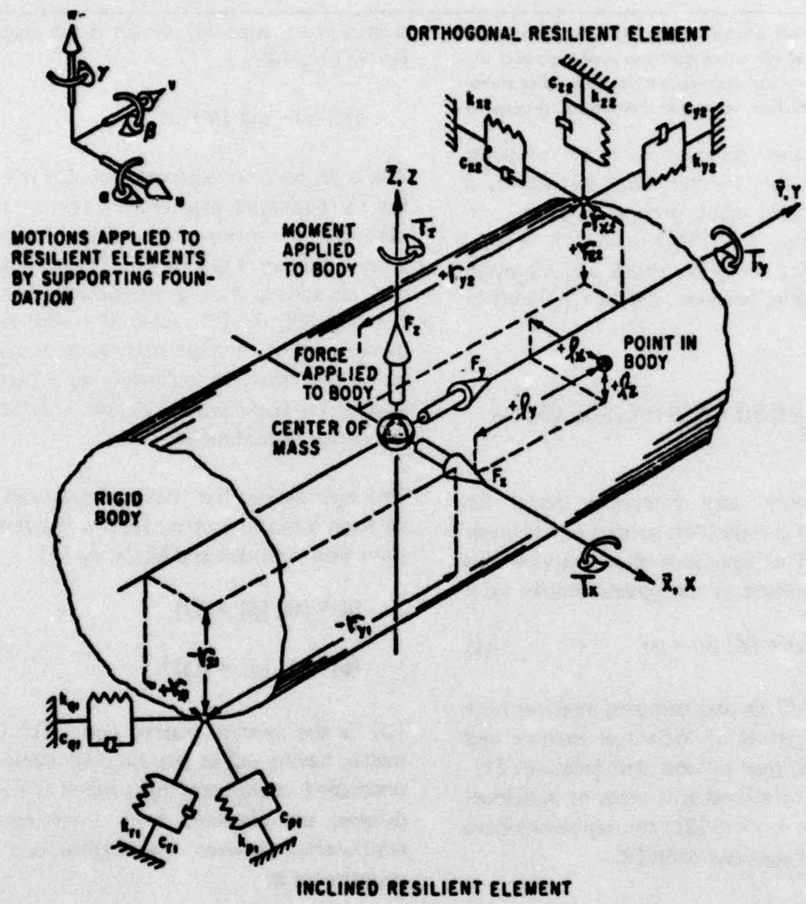


FIGURE 1. Analytical Model for Response of a Rigid Mass on Isolators

proportional to ω_n. In the most general case, the values of ζ_n can be any set of numbers. Damping can be handled by assigning values of ζ_n for each mode. The simplest approach is to form the [C] matrix, transform equation (8), and neglect the off-diagonal terms (see [7] for a discussion and for other ways to handle damping).

Substitute equation (7) in equation (1) and multiply the result by $[\phi]^t$ to obtain the matrix equation

$$(\ddot{\eta}) + [D](\dot{\eta}) + [\Omega]^2(\eta) = [\phi]^t(f) \tag{9}$$

The matrix equation is uncoupled because [D] and $[\Omega]$ are diagonal matrices. The n^{th} equation can be written as

$$\ddot{\eta}_n + 2\zeta_n\omega_n\dot{\eta}_n + \omega_n^2\eta_n = \sum_{i=1}^{6} \phi_{in} f_i = P_n \tag{10}$$

$$(n = 1 \text{ to } 6)$$

It is assumed that the input vector (f) is given and after the eigenvalue problem has been solved, the natural frequencies contained in the diagonal matrix $[\Omega]$ and the mode shapes contained in the modal matrix $[\phi]$ are known so that the six equations represented by equation (10) can be solved.

For shock problems each equation can be solved individually, using the exact solution assuming that the time history is a series of straight lines between the digitized values representing the time history. Knowing the initial conditions at any point in time, t_i, the solution is advanced to the next point in time, $t_i + 1$, assuming that the input is represented by a straight line between the values given at t_i and $t_i + 1$. It is conventient to solve these equations in terms of quantities with dimensions of acceleration.

$$f_n = \omega_n^2 \eta_n \tag{11}$$

$$g_n = \omega_n \dot{\eta}_n \tag{12}$$

$$\ddot{\eta}_n = P_n - f_n - 2\zeta_n g_n \tag{13}$$

The values of f and g that advance the solution from t_i to $t_i + 1$ can be written in matrix form as

$$\begin{Bmatrix} f_{i+1} \\ g_{i+1} \end{Bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{Bmatrix} f_i \\ g_i \end{Bmatrix} + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{Bmatrix} P_i \\ P_{i+1} \end{Bmatrix} \tag{14}$$

where $f_i = f(t_i)$.

$$\tau = \omega\,(t_{i+1} - t_i) \tag{15}$$

$$\beta = \sqrt{1-\zeta^2} \tag{16}$$

$$a = e^{-\zeta\tau}\cos(\beta\tau) \tag{17}$$

$$b = \frac{1}{\beta}\, e^{-\zeta\tau}\sin(\beta\tau) \tag{18}$$

The coefficients of the A and B matrices are

$$A_{11} = a + \zeta b \tag{19}$$

$$A_{12} = b \tag{20}$$

$$A_{21} = -b \tag{21}$$

$$A_{22} = a - \zeta b \tag{22}$$

$$B_{11} = 2\zeta/\tau - \left(\frac{2\zeta}{\tau} + 1\right) a - \left(\frac{2\zeta^2 - 1}{\tau} + \zeta\right) b \tag{23}$$

$$B_{12} = 1 + 2\zeta/\tau(a-1) + \left(\frac{2\zeta^2-1}{\tau}\right) b \tag{24}$$

$$B_{21} = b - \frac{1}{\tau}(1 - a - \zeta b) \tag{25}$$

$$B_{22} = \frac{1}{\tau}(1 - a - \zeta b) \tag{26}$$

This form of the solution to equation (10) has been published [8]. The values of (x), $(\dot{x})$, and $(\ddot{x})$ are obtained from the values of (η), $(\dot{\eta})$, and $(\ddot{\eta})$ using equation (7).

For steady-state solutions the equation (10) is solved using the complex Fourier transform

$$T_n^* = \frac{1}{\omega_n^2 - \omega^2 + j(2\zeta_n\omega_n\omega)} \tag{27}$$

so that $\eta_n^* = T_n^* P_n^*$; η_n^* and P_n^* are the Fourier transforms of η_n and P_n, respectively. The amplitude and phase of η^* are the steady-state responses represented by P_n [9].

Different techniques are used to handle the nonlinear effects described in the next section.

Nonlinear Effects
Nonlinear effects associated with isolators involve stiffness and damping. Common stiffness effects include stiffening, softening, buckling, abrupt bottoming, and preloaded springs. Common damping effects include Coulomb friction and hysteretic damping [10]. If the isolator can be approximated by a linear spring and viscous damper, linear methods can be used. Methods have been described for sinusoidal vibration [11] and random vibration [12, 13]. Methods used to solve nonlinear shock problems have been discussed [4. 14]. The Newmark β method is commonly used [15]. The computer solution of a nonlinear problem can be considerably more expensive than that of a linear one because the response of each isolator must be calculated. The modeling of a nonlinear shock isolation system and a comparison of the computer solution with experimental results have been published [16]. Modeling techniques for digital computer analysis of nonlinear shock isolation systems have been described [17].

SPECIAL PROBLEMS

Many special problems in the field of shock and vibration isolation can be solved with the aid of digital computers. Some of them are outlined below.

Optimum Shock Isolation
The shock isolation of large underground protective structures advanced the design of optimum shock isolation systems. The required rattlespace must be minimized, and the isolated equipment or structure must be protected to a given fragility level. Shock inputs can be precisely defined or defined within limits. Techniques for solving these problems -- many requiring a digital computer -- have been published [18].

Structureborne Sound
Structureborne sound is very high frequency mechanical vibration. At the high frequencies involved, neither the isolated equipment nor the structure to which the isolators are attached can be considered rigid. The problems can be analyzed with large general purpose computer programs or with small special purpose ones [19].

Rigid Body Parameters
A package to be isolated is often composed of many parts. Analysis of a rigid body requires determination of the center of gravity, total weight, and moments of inertia. The calculations can be efficiently performed by a small special purpose computer program.

Shock Spectra
The computation of shock spectra has been discussed [20]. The shock and vibration analyst may use shock spectra to determine the natural frequency and damping required to protect a rigid body to a certain acceleration level and to determine the required isolator deflection. Shock spectra of the motion of a rigid body supported by isolators are also used as criteria for shock isolation.

Decoupling Rotation from Translation
It is often desirable to minimize rotational response of an isolated package. Techniques have been described that require computer programs [2, 21].

Design of Isolators
Isolator properties can be used to aid physical design. The stress analysis of elastomeric isolators is complicated because the elastomer has a Poisson's ratio of about 1/2, it is viscoelastic, and undergoes large deflections. Three general purpose computer programs are available: TEXGAP [22]. VISCOSUPERB [23], and MARC [24]. All are adequate for a Poisson's ratio of 1/2, but only VISCOSUPERB and MARC can be used to analyze viscoelastic materials and large deflections. A procedure for the analysis of elastomeric mounts using standard statistical programs has been published [25].

COMPUTER PROGRAMS

Unfortunately, few computer programs on shock and vibration isolation have been published. Although the author has written many programs, they have not been published and thus are not generally available. Brief descriptions of programs related to shock and vibration isolation that are available in the literature are given below.

General

The VIP (Vibration Isolation Program) computes the response of a rigid mass supported by as many as ten isolators [26]. The inputs are either random or sinusoidal translations at each isolator. Each isolator is represented by a linear spring and viscous damper in parallel. A restriction is that the principle stiffnesses of all isolators must be along the same axis as the principle moments of inertia of the mass. Response values are printed and plotted, and the response of a transfer function describing response characteristics for any electromechanical device relating to linear or angular acceleration will be plotted. This is useful for studying the response of gyros. The program listing is included in the cited reference.

A program that computes the transient response of a rigid mass supported by nonlinear isolators has been described [27]. One plane of symmetry is assumed, so that there are only three degrees of freedom. The input is a motion of the base to which the isolators are attached. The program listing and description are included in Appendix C [27].

The natural frequencies and normal modes of vibration for a compound isolation mounting system have been determined with a computer program [28]. The model is a rigid mass supported by a set of linear springs attached to a second rigid mass that is supported by a set of linear springs attached to ground. The program listing is not given.

The ISOLATOR Program [29] computes the response of a single degree of freedom of an isolation system to a finite arbitrarily shaped pulse for various types of isolators. A general nonlinear model is used for gross response and a linear rod for local isolator response. A Runge-Kutta-Gill integration routine is used to calculate gross response, and a central difference scheme is used to determine local response. Theoretical and experimental results are compared.

Underground Structures

A program that computes the dynamic response of a multistory building model subjected to an earthquake or blast-type base motion has been reported [30]. Assumptions concerning the model are: the structure is considered to be a lumped mass system; the resistance of the columns of each story can be represented by a bilinear shear string; the damping is such that, when the sytem is elastic, the classical normal modes exist; and vertical motion may be neglected. The program listing is given.

A computer program that determines shocks that cause failures of isolators is available [31]. The isolators are modeled as linear springs to bottomed height and as stiff linear springs to failure load. A platform and the equipment attached to it are modeled as 12 masses connected by stiff springs. The appendix describes a numerical procedure for computing tangent motion. The program is available through the U.S. Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

Optimum Shock Isolation

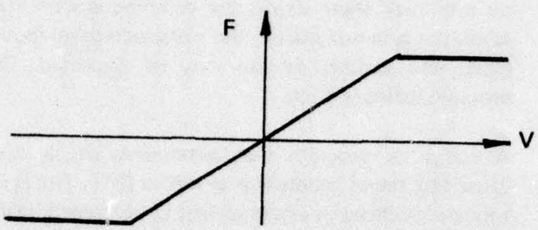
A computer program for determining a force-deflection curve in order to optimize a shock isolator has been published [32]. The objective is to minimize the response spectra of the isolated package rather than the peak acceleration. A simple pulse provides the shock input.

The OPSHK (Optimum Passive Shock Isolation) program determines the six degree of freedom response of a rigid mass on a specific type of isolators to a set of specific input wave forms [33, 20]. The computer formulation considers the geometry change due to large deflections.

Other specific isolator programs [34, 35-39] include POSI (Passive Linear Optimum Shock Isolation), NOSI (Passive Nonlinear Optimum Shock Isolation), COSI (Configuration-Free Optimum Shock Isolation), OPTIMA (CDC Linear Programming), and POSTLP (Post Linear Program). Descriptions, flow charts, and program listings are given for POSI, NOSI, COSI, and POSTLP. These programs determine optimum isolator parameters for a three degree of freedom model that minimizes the maximum acceleration experienced by a structure subjected to ground shock

waves in the vertical and/or horizontal directions when rattlespace restraints are placed on the system.

A time-sharing program is available that computes the response of a single degree of freedom isolation system having a damping force as a function of velocity; it is shown in the sketch below [40].



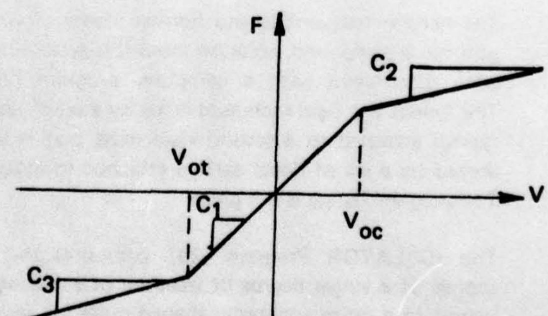
The optimum results are compared to the theoretical optimum. The program listing is not given, but it is available from the author upon request.

Vehicle Suspensions

Two computer programs have been used to calculate the three dimensional dynamics of a rigid high-speed ground vehicle supported vertically and laterally with an arbitrary number of suspensions and excited by arbitrary inputs [41]. With the LINEAR-ELEMENT computer program, suspensions are modeled by a linear spring and damper in parallel; these are connected to the unsprung mass. Another linear spring and damper in parallel join the unsprung mass and the vehicle. In the ARBITRARY-ELEMENT computer program, suspensions are modeled as nonlinear and/or "active" elements that are part of the MIDAS program [42]. Program listings are given.

A computer program has been used to evaluate the response of railroad cars to rail [43]. The program is used to optimize the stiffness in damping of the suspensions system. A program listing is not given.

The response of a single degree of freedom isolation system to arbitrary inputs has been calculated using a computer [44]. The isolator is modeled as a linear spring in parallel with a nonlinear damper having a force as a function of velocity as shown in the adjacent sketch.



This model is used to represent automobile shock absorber characteristics. The computer program listing is given.

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BOOK REVIEWS

INTRODUCTION TO GASDYNAMICS OF EXPLOSIONS

Antoni K. Oppenheim
Springer-Verlag, New York

Introduction to Gas Dynamics of Explosions is a small book developed from course notes covering original research. It is unique amoung books originating in this manner in that the first equations appear on page 95 of the 200-page book: fully half the book consists of a nonmathematical description of the phenomena involved.

The basis for the exposition lies in the author's conviction that an effort to draw the various aspects of this complex subject together has not been satisfactorily accomplished. He expends considerable effort in an introduction that includes those aspects of compressible fluid mechanics not often considered, namely phenomena that occur when the rate of energy conversion is significant. In his description of phenomena, which is enhanced by photographs and diagrams, the author explains the phenomena being modeled before he begins the mathematical modeling process.

The book is organized into four chapters.

- "GENESIS AND SUSTENANCE: The Birth and Life of an Explosion"
- "EVOLUTION OF GASDYNAMICS OF EXPLOSION: The Dynamics of Exothermic Processes"
- "GASDYNAMIC DISCONTINUITIES: The Most Prominent Effects of Explosions"
- "BLAST WAVES: The Flow Fields of Explosions"

In the first chapter the mechanics of explosions are described using the processes that occur in a linear shock tube. Many fine photographs and diagrams complement the explanation of the basic phenomena of detonation waves. The presentation is clear and illustrates the analysis that follows in chapter three.

In an interesting section called "Technological Significance" the explosion processes are placed within a classification scheme of power producing processes in an attempt to predict future achievements. Chapter two is both a history of previous work on the entire process and a classification of the various subfields. Discussions of decaying, amplifying, and sustaining wave systems are given. Chapter three contains an analytical derivation of the equations governing discontinuities in a flow. There is no a priori assumption of a particular form for the equation of state. This permits a good model to be developed for a particular mixture of gases. Analytical predictions and experimental measurements are evidence of the success of the effort. Chapter four reviews the theory of blast waves and compares previous treatments; a table permits comparisons among various non-dimensional parameters that have been defined by seven authors in the field. The form of the equation of state is discussed and is set in both Eulerian and Lagrangian descriptions. Solutions of special case results are given.

References are given in each chapter. The first chapter is particularly valuable as an introduction for those with a casual or management interest in the field. One problem is typographical errors within the text. It is hoped that the mathematics and the figure captions were proofread more thoroughly. One should use caution in extracting any figure or equation without independently verifying it.

R. L. Woodfin, Ph.D.
Head, Environmental Engineering Branch
Department of the Navy
Naval Weapons Center
China Lake, CA 93555

FINITE ELEMENT ANALYSIS FUNDAMENTALS

R.H. Gallagher

Prentice Hall, Inc., Englewood Cliffs, New Jersey (1975)

The title implies that the book is fundamental, but it contains the matrix displacement analysis method of structures. This subject will be applicable to future studies in finite element analysis. The mathematics is sometimes difficult. The author claims that some familiarity with the theory of elasticity, matrix structural analysis, and partial differential equations is required.

A brief history of finite elements is followed by general information on coordinate systems, the idealization of basic elements, element force displacement properties, the representation of flexibility stiffness, rigid body modes, procedures for global analyses, and the constitution of finite elements. The relationships of elasticity theory and the self-compilation of models for large structures are described.

The direct methods of finite elements, the method of weighted residuals, and the direct method are discussed. The finite element formulation is dealt with from the variational point of view -- i.e., minimum potential and complimentary energy formulation; variational methods are now used in global analysis of structures. The reviewer believes that hybrid methods should have been discussed in greater detail because of their impact on finite element theory.

The author stresses assumed displacement functions and their importance in element formulation. He discusses Lagrangian interpolation and the Hermitian interpolation used in higher order elements. The author derives triangular elements, tetraheoronal elements, and describes isoparametric element relationships. He deals with plane strain of triangular and rectangular elements, methods of interpolating stress results, and hybrid stress formulation. He formulates solid elements (tetrahedronal and hexahedronal).

Both are important in three-dimensional finite element studies, but the isoparametric relationships are considered only briefly. The reviewer believes that the latter will assume a more important role in three-dimensional studies, especially the 20 node brick (hexahedronal element).

The author considers special cases of solid elements (plane strain, axisymmetric solids) with non-axisymmetric loads and symmetric loads.

The basic relations of flat plate bending are given, as well as assumed displacement models in both single field and subdomain formulations, mixed stress-displacement formulation as expounded by Dr. Pian and deflections due to shear deformation of beams and plates.

Finally, the author considers elastic instability analysis and directly applies it to flexural buckling, torsion flexure buckling, and framework stability.

The reviewer believes that this book will benefit both the novice and the expert. However, no dynamic analysis of finite element formulation was considered. In addition, Dr. Gallagher should have discussed finite element models in fracture mechanics. Such models are assuming greater importance.

The reviewer feels that this book belongs on the shelf of engineers who use finite element theory.

Herb Saunders
General Electric Co., LSTGD
Schenectady, New York 12345

NEWS BRIEFS

news on current
and Future Shock and
Vibration activities and events

EUROPEAN MECHANICS COLLOQUIUM
EUROMECH 89

An informal conference on vibration control by damping, sponsored by the European Mechanics Committee, will be held 22 - 24 June, 1977, in Lyon, France. Participation is restricted to a small number of European research workers actively engaged in the field. The organization of this Colloquium, including the selection of participants for invitation, is entrusted to the Chairman--Prof. M. Lalanne. People who are interested in taking part in the seminar should write to him at the following address:

Prof. M. Lalanne
Laboratoire de Mécanique des Structures,
Bât. 113 - INSA
20, avenue Einstein
F-69621 Villeurbanne, Cedex, France

ARTICLE CORRECTION

The title of the article "Dynamics of Composite and Sandwich Panels" by Professor Charles Bert was incorrectly listed in the October and November issues of the **DIGEST**.

NOISEXPO '77
CALL FOR PRESENTATIONS

Technical papers, films, and other presentations are now being solicited for NOISEXPO '77, the National Noise and Vibration Control Conference and Exhibition scheduled for March 14 - 17, 1977 at the Holiday Inn, O'Hare/Kennedy, five minutes from Chicago's O'Hare Airport. The program will accommodate a series of concurrent technical sessions organized by topical interest, a series of short courses, and specialized workshops. A completely equipped mini-theater will be available for the presentation of motion picture films, automated slide-presentations and other specially prepared audio/visual material. Subjects of interest include: In-Plant Noise Control, Product Noise and Vibration Control, Structural Dynamics, Community Noise Regulation, Hearing Conservation, Noise and Vibration Measurements, and Federal Noise Regulations.

Additional information is available from:

NOISEXPO '77
27101 E. Oviatt Road
Bay Village, OH 44140
Telephone: (216) 835-0101

SHORT COURSES

FEBRUARY

PREVENTIVE MAINTENANCE AND FAULT DIAGNOSIS

Dates: January 31, February 1 & 2, 1977

Place: University of Houston Hotel

Objective: This seminar is devoted to the understanding and application of vibration technology to machinery preventive maintenance programs and fault diagnosis problems. Basic and advanced techniques with illustrative case histories and demonstrations will be discussed by industrial experts and consultants. Topics to be covered in the seminar include development of preventive maintenance programs; measurements, analysis, and data reduction, shock pulse techniques for bearing analysis; computer monitoring; and acoustic techniques. An instrumentation show will be held in conjunction with this seminar.

Contact: Dr. R. L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 Tele. (312) 654-2254/654-2053

INTRODUCTION TO VIBRATION AND SHOCK

INTRODUCTION TO VIBRATION AND SHOCK TESTING, MEASUREMENT, ANALYSIS AND CALIBRATION

Dates: February 14 - 18, 1977

Place: Santa Barbara, California

Objective: This course will benefit plant engineers and maintenance personnel responsible for on-line condition analysis of rotating machinery. Electronic techniques for analysis of vibration and sound signatures in terms of specific machinery faults will be discussed. This course will concentrate upon equipments and techniques rather than upon theory.

Contact: Mr. W. Tustin, Tustin Institute of Technology, Inc., 22 E. Los Olivos St., Santa Barbara, CA 93105 Tele. (805) 963-1124

MACHINERY VIBRATION ANALYSIS

Dates: February 15 - 17, 1977

Place: Lanham, Maryland

Objective: This course will cover such areas as fundamentals of vibration, vibration and analysis, transducer concepts, machine protection systems, analyzing vibration to predict failures, reducing unbalance forces, reducing misalignment forces, interpreting vibration signatures, improving analysis capability, and managing vibration data by computer.

Contact: Mr. Bob Kiefer, Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 Tele. (714) 565-8211

MODELING IN ENGINEERING DYNAMICS

Dates: February 28 - March 4, 1977

Place: San Antonio, Texas

Objective: This course is recommended for prospective students who have a bachelor's degree in some field of engineering, physics, or mathematics. The intent of this course is to introduce and illustrate to engineers, physicists, and scientists investigating transient phenomena the powerful tool of model analysis, and although the course is directed toward experienced personnel, a newcomer to the fields of survivability analysis, terminal ballistics effects, safety engineering, engineering dynamics, etc., can keep pace by diligently applying himself.

Contact: Mr. Peter S. Westine, Southwest Research Institute, P.O. Box 28510, San Antonio, TX 78284

MARCH

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS

Dates: March 7 - 11, 1977
Place: UCLA
Objective: This course covers the latest practical techniques of correlation and coherence analysis-- ordinary, multiple and partial -- for solving acoustics and vibration problems in physical systems.

Contact: Continuing Education in Engineering and Mathematics, Short Courses, 6266 Boelter Hall, UCLA Extension, Los Angeles, CA 90024
Tele. (213) 825-1047

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 14 - 19, 1977
Place: Phoenix, Arizona
Objective: Program emphasis is on how to obtain valid cost-effective data in the field and in the laboratory during the next decade through increased productivity of data acquisition systems and groups. The latest developments in the new Unified Approach to the Engineering of Measuring Systems to achieve these aims, will be presented.

Contact: Prof. P. Stein, Short Course Director, 5602 East Monte Rosa, Phoenix, AX 85018
Tele. (602) 945-4603/965-3124

MAY

FINITE ELEMENT METHOD AND NASTRAN USAGE

Dates: May 16 - June 16, 1977
Place: Washington, D.C.
Objective: A sequence of three professional development courses will be presented to provide an understanding of the technological content in general purpose finite element programs; and to provide training in the use of NASTRAN. The courses and dates are:

- oTheory of Finite Elements, May 16 - 20, 1977
- oStatic Structural Analysis Using NASTRAN, May 23 - 26, 1977
- oDynamic and Nonlinear Structural Analysis Using NASTRAN, June 14 - 27, 1977

Contact: Dr. H. Schaeffer, Schaeffer Analysis, P.O. Box 761, Berwyn Station, College Park, MD 20740
Tele. (301) 721-3788

STANDARDS REVIEW

INTERNATIONAL STANDARDS ORGANIZATION TECHNICAL COMMITTEE 108

Meetings of ISO/TC 108 and ISO/TC 108/SC1 were held in London in September, 1976; the working groups also met. Thirty delegates representing 11 countries attended the meetings. Excerpts from reports of various working groups are given below. A more detailed report is available from the ASA Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017.

ISO/TC 108 Organization

The U.S. is now officially responsible for the Secretariats of SC1 and SC3. The TC 108 Secretariat administers the Secretariat of SC1; the National Bureau of Standards (NBS) administers the Secretariat of SC3. The NBS has relinquished responsibility for the Secretariat of SC3. Denmark has indicated willingness to assume this activity.

At the TC 108 meeting in London, the desire of several groups to establish formal or closer liaison with TC 108 was noted. These groups include TC 8, Shipbuilding Details; the International Labor Organization (ILO); and the International Organization of Legal Metrology (OIML). It was suggested that the European Economic Community (EEC) have direct liaison with TC 108.

It is proposed that Working Group 6 of Subcommittee SC1, Balancing Equipment for Special Applications, should be disbanded and a new working group formed. The new group would be SC1/WG7, Review of Balancing Standards and Specifications other than of TC 108. The scope of the group would include the compilation of standards pertaining to balancing and balancing machines that have been issued by groups other than TC 108, and the conversion of such standards to ISO 1925 terminology and ISO 1940 criteria.

It was proposed that TC 108/WG4 change its title to Vibration Testing Equipment. The scope of the group would be to develop international standards for vibration testing equipment -- e.g., electrodynamic and hydraulic testing equipment -- and auxiliary tables. It was proposed that ISO/TC 108/SC1/WG4, Mass Properties of Free Aerospace Bodies, develop a document entitled description and evaluation of scales for measuring centers of gravity for free aerospace bodies.

Individual Reports of Working Groups

The TC 108 Secretariat will request that the ISO Central Secretariat send copies of ISO 2041-1975 to organizations concerned with shock and vibration technology for use and comment. The document on Auxiliary Tables for Vibration Generators is being prepared for TC 108 vote. The document on Electrodynamic Testing for Generating Vibration Methods of Describing the Characteristics of the Equipment is to be submitted to the combined voting procedures of ISO. The document entitled Guide for Selecting and Applying Resilient Shaft Couplings will be submitted for vote as a Draft Proposal. It was recommended that ISO 2017-1972 Vibration and Shock - Isolators - Characteristics for Mechanical Isolation be reaffirmed. The document being considered on Analog Methods for the Analysis and Presentation of Vibration and Shock Data will be combined with the document on Digital Methods of Analyzing Vibration and Shock Data and prepared as a new Draft for a Technical Report.

ISO/TC 108/WG11, Design Evaluation Methods for Vibration and Shock, a new working group, held its first meeting in London. The convener will be Meier-Dornberg; the USA holds the Secretariat.

The ISO/TC 108 Secretariat Steering Committee on Shock is an ad hoc group established at the September, 1975, meeting of TC 108. The group has prepared a first draft proposal entitled Standards for Shock Testing, which was circulated for comment.

The scope of the committee has been changed. It is now to provide necessary external liaison, technical coordination within TC 108, and technical support to the TC 108 Working Groups and Subcommittees in the area of mechanical shock. This includes the initiation of pertinent drafts of technical documents.

ISO/TC 108/SC1/WG1, Balancing Terminology, is working on terminology relating to rotating rigid free bodies. The SC1 Secretariat is arranging for terms and definitions agreed upon by SC1/WG1 to be processed under the combined voting procedures of ISO. SC1 agreed that the amendments to ISO 1925 Balancing Vocabulary, as agreed upon by SC1/WG1, shall be submitted to the combined voting procedure of ISO.

ISO/TC 108/SC1/WG2, Balancing Criteria for Flexible Rotors, has considered two draft proposals. The document on The Mechanical Balancing of Flexible Rotors will be submitted by SC1 to the combined voting procedure of ISO. The document on Criteria for Evaluating Flexible Rotor Balance is being prepared for SC1 vote at the Draft Proposal stage.

ISO/TC 108/SC1/WG3, Field Balancing Equipment, was disbanded with thanks for the work completed.

The scope of ISO/TC 108/SC1/WG4, Mass Properties of Free Aerospace Bodies, as discussed in SC1 and modified by TC 108, is to develop International Standards concerned with the mass properties of free aerospace bodies and recommended definitions of terms related to this field. A document is to be developed for the description and evaluation of scales for measuring centers of gravity for free aerospace bodies. Further recommendations of SC1/WG4 will be submitted on the measurement of moments of inertia, products of inertia, and aerodynamic contours.

The members of ISO/TC108/SC1/WG6, Balancing Equipment for Special Applications, decided to collect, from their respective countries, standards pertaining to balancing and balancing machines that have been issued by societies, associations, or agencies other than ISO. The committee will change the standards to ISO 1925 Terminology and ISO 1940 Criteria and urge their acceptance by the original issuer. It was also decided that SC1/WG1 on Balancing Terminology should review a suggested nomenclature to be used in future work of WG6 and define a series of suggested new terms incorporation into ISO 1925. The nomenclature and terms are to be submitted by SC1/WG6. SC1/WG6 recommended, and SC1 accepted, that attempts to use SAE 587 for an ISO standard should be dropped because the document has already been converted to ISO terminology. Similarly, an attempt to adopt ISO 2953 in place of an American Defense Supply Agency (DSA) Standard for gyroscope balancing machines should be discontinued; the methods outlined in the first paragraph above are to be used instead.

The document on Evaluation and Measurement of Vibration in Buildings was sent to ISO/TC 108/SC2 on Measurement and Evaluation of Mechanical Vibration and Shock as Applied to Machines, Vehicles and Structures for a vote. Informal meetings of SC2/WG1, Vibration of Machines, and SC2/WG4, Measurement and Evaluation of Vibration and Shock in Land Vehicles, were also held during the TC 108 meetings. Reports on those meetings are available from the Secretariat of SC2 (DIN).

A meeting of ISO/TC 108&SC4 on Human Exposure to Mechanical Vibration and Shock and its Working Groups took place in September, 1976, in St. Vincent, Valley of Aosta, Italy. The draft resolutions of this meeting will be published in the next **DIGEST** Standards Review.

The document on Nomenclature for Specifying Damping Properties of Materials, developed by TC 108/WG5 will be submitted for combined voting after it has been edited and modified. ISO/DIS 3945, Measurement and Evaluation of Vibration Severity of Large Rotating Machines in Situ, Operating at Speeds from 10-200 rps (developed by ISO/TC 108/SC2), is being revised in accordance with comments received following ISO Council vote. A second Draft International Standard of ISO/DIS 3719, Symbols for Front Panels of Balancing Machines, is being prepared as a result of voting on this document.

AMERICAN NATIONAL STANDARDS INSTITUTE COMMITTEE S2

A meeting of Standards Committee S2, Mechanical Shock and Vibration, which serves as the technical advisory group for ISO/TC 108 on Mechanical Vibration and Shock, met in Albuquerque, New Mexico on 21 October 1976. An excerpt of some of the reports presented at that meeting is given below. Further information on S2 activity may be obtained from the ASA Standards Secretariat.

The revision of S2.4-1960 (ASA STD. 8-1976) Method for Specifying the Characteristics of Auxiliary Equipment for Shock and Vibration Measurements was approved by ANSI and published by ASA. Mr. Hancock reported that a meeting of S2-43 (S1) on Testing Electronic Components in High Level Sound Fields will be held in conjunction with the IES meeting and that recommendations would be forthcoming following that meeting.

Several international documents on acoustical terminology were submitted to S2 for comment by S1-53 (S2, S3). At the meeting, it was proposed that ISO 2041-1975 be proposed as an ANSI Standard. Proposals were made to prepare a separate document that specifically relates to mechanical vibration and shock and would possibly incorporate the definitions in ISO 1925 Balancing Terminology.

Mr. Reed reported that the document prepared by S2-54, Atmospheric Blast Effects, had been submitted for a letter ballot.

It was decided at the meeting of S2-55 on Vibration Levels of Machines, Ships and Structures that the three subgroups of S2-55 would form three new working groups and that S2-55 would be disbanded. Accordingly, the three new working groups will be: S2-76 Machines, chaired by P. Maedel; S2-77 Ships, chaired by E.F. Noonan; and S2-78 Structures, chaired by R. Scavuzzo.

It was decided that since the work of S2-65, Auxiliary Equipment for Shock and Vibration Measurements, ended with the publication of ASA STD. 8-1976 (S2.4-1976), the group should be disbanded. Mr. Nelson, chairman of S2-64, proposed that a new exploratory working group (S2-79) be established to study specifications for digital analyzers used in conjunction with shock and vibration measurements. S2 decided to take this direction, and Mr. Nelson agreed to chair the new group and submit a report in April, 1977.

Liaison will be established between S2-65, Balancing Technology, and the new S2-76 Committee on Machines. This liaison parallels international activities involving SC1 and SC2. It was reported that S2-69 on Seismic Testing expects to have an international document ready by April, 1977. Mr. Mitchell reported that his group, S2-71 on Techniques of Machinery Vibration Measurement, is preparing a second draft of the document on Techniques of Machinery Vibration Measurement. It had been expected that the draft to S2 would be submitted in November, 1976.

S2-72 on Vibration Testing, established as an exploratory group, has become an official working group. The objective of the group is to prepare one or more standards covering all aspects of vibration testing. It is possible that technical reports rather than standards will be written. This working group will also monitor the work of TC 108/WG4 on Vibration Testing.

Mr. Baade's working group S2-74 on Experimental Measurement of Structural Impedances has prepared a document that will be submitted for ballot in the near future. The title of the document has been changed to "the measurement of mechanical mobility" for technical reasons.

It was recommended that two existing standards more than five years old be reaffirmed. The standards are S2.8-1972 Guide for Describing the Characteristics of Resilient Mountings, and S2.15-1972 Specifications for the Design, Construction, and Operation of Class HI (High Impact) Shock-Testing Machines for Lightweight Equipment. These recommendations will be submitted to S2 ballot.

Avril Brenig
Standards Manager

ABSTRACT CATEGORIES

ANALYSIS AND DESIGN

Analogs and Analog Computation
Analytical Methods
Dynamic Programming
Impedance Methods
Integral Transforms
Nonlinear Analysis
Numerical Analysis
Optimization Techniques
Perturbation Methods
Finite Element Modeling
Modeling
Digital Simulation
Parameter Identification
Design Information
Design Techniques
Criteria, Standards, and Specifications
Surveys
Tutorial
Mode Synthesis

COMPUTER PROGRAMS

General
Natural Frequency
Random Response
Stability
Steady State Response
Transient Response

ENVIRONMENTS

Acoustic
Periodic
Random
Siesmic
Shock
General Weapon
Transportation

PHENOMENOLOGY

Composite
Damping
Elastic
Fatigue
Fluid
Inelastic
Soil
Thermoelastic
Viscoelastic

EXPERIMENTATION

Balancing
Data Reduction
Diagnostics
Equipment
Experiment Design
Facilities
Instrumentation
Procedures
Scaling and Modeling
Simulators
Specifications
Techniques
Holography

COMPONENTS

Absorbers
Shafts
Beams, Strings, Rods
Bearings
Blades
Columns
Controls
Cylinders
Ducts
Frames
Gears
Isolators
Linkages
Mechanical
Membranes, Films, and Webs
Panels
Pipes and Tubes
Plates and Shells
Rings
Springs
Structural

SYSTEMS

Absorber
Acoustic Isolation
Noise Reduction
Active Isolation
Aircraft
Artillery
Bioengineering
Bridges
Building
Cabinets
Construction
Earth
Electrical
Foundations
Helicopters
Human
Isolation
Material Handling
Mechanical
Metal Working and Forming
Off-Road Vehicles
Optical
Package
Pressure Vessels
Pumps, Turbines, Fans, Compressors
Rail
Reactors
Reciprocating Machine
Road
Rotors
Satellite
Self-Excited
Ship
Spacecraft
Structural
Transmissions
Turbomachinery
Useful Application

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, Va., 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM). 313 N. Fir St., Ann Arbor, MI. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

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ANALYSIS AND DESIGN

ANALOGS AND ANALOG COMPUTATION

(See No. 7)

ANALYTICAL METHODS

(Also see No. 19)

77-1

Transmission and Reflection of Extensional Stress Pulses at the Junction of a Straight Bar and a Helix

D.W. Haines and N. Chang

College of Engrg., Univ. of South Carolina, Columbia, SC., J. Appl. Mech., Trans. ASME, 43 (2), pp 309-313 (June 1976) 6 figs, 8 refs (presented at Nat'l. Conf. of Appl. Mechanics, Univ. of Utah, Salt Lake City, UT., June 15-17, 1976, of ASME).

Sponsored by the National Science Foundation

Key Words: Curved beams, Mechanical filters, Fourier transformation, Frequency response

An analytical and experimental study of a mechanical pulse filter is reported. The filter is an unbounded assembly composed of a straight bar joined tangentially to a helix. The Fourier time transform of the pulses and the complex frequency response of the assembly are employed to obtain the analytical solutions. Experimental results are presented which verify the analytical solution.

77-2

Dynamic Characteristics of a Structure with Modifications at its Supports

S. Mahalingam

Dept. of Mechanical Engrg., Univ. of Sri Lanka, Sri Lanka, J. Mech. Engr. Sci., 18 (3), pp 113-120 (June 1976) 6 figs, 7 refs

Key Words: Supports, Free vibration, Forced vibration

The paper is concerned with the free and forced vibrations of an undamped system in which rigid supports are removed or replaced by new subsystems. Since the modifications involve the constraints of the system, special techniques based on the receptances and transfer ratios associated with displacement excitation at a support are employed. The results are formulated in the modal parameters of the whole of the original unmodified system and any added subsystems; the characteristics of the removed subsystem play no part in the solution. Starting with the problem of the removal of one or more rigid supports, the analysis is extended to modifications of a greater complexity at the supports.

77-3

The Critical Behavior of the Anharmonic Oscillator

D. Isaacson

Ph.D. Thesis, New York University, 75 pp (1976) UM 76-19, 509

Key Words: Oscillators, Eigenvalue problems

All the eigenvalues, eigenfunctions, and Schwinger functions of the ordinary differential operator

$$H(\lambda, m) = \frac{1}{2}\,[p^2 + \lambda q^4 + (m^2 - \lambda m^{-1})q^2]$$

are studied as $\lambda \to \infty$.

77-4

Some Properties of the Generalized Van der Pol Equation

N. Van Dao

Polish Academy of Sciences, Inst. of Fundamental Technological Research, Warszawa, Poland, Journal of Technical Physics, 17 (2), pp 183-190 (1976) 4 figs, 2 refs

Key Words: Van der Pol method, Vibration response

Some properties of the generalized Van der Pol equation $\ddot{x} + \omega^2 x - \epsilon[1 - (x + q\cos\nu t)^2]\,\dot{x} = 0$ are reviewed.

77-5

Non-Linear Forced Vibrations of Symmetric Systems by Group Representation Theory

A.K. Mishra and M.C. Singh

Polish Academy of Sciences, Inst. of Fundamental Technological Research, Warszawa, Poland, Journal of Technical Physics, 17 (2), pp 171-181 (1976) 1 fig, 12 refs

Key Words: Forced vibration, Nonlinear systems

For geometrically symmetric spring mass systems group representation theory is employed to simplify forced non-linear vibrational analysis. The group representation theory is used to determine the normal modes of free linear and free non-linear systems. Forced linear systems have also been analyzed for normal modes of vibration by this procedure.

77-6

Stability, Convergence and Growth and Decay of Energy of the Average Acceleration Method in Nonlinear Structural Dynamics

T.J.R. Hughes

Div. of Structural Engrg. and Structural Mechanics, Dept. of Civil Engrg., Univ. of California, Berkeley, CA 94720, Computers and Struc., 6 (4/5), pp 313-324 (Aug/Oct 1976) 8 figs, 21 refs

Key Words: Average acceleration method, Nonlinear systems, Dynamic structural analysis

The subject of this paper is the stability, convergence and growth and decay of energy of the average acceleration method applied to a class of linear and nonlinear elastic problems encountered in structural dynamics. A discrete energy identity is obtained and the cause of the spurious growth and decay of energy, noted in nonlinear problems, is exhibited.

77-7

Theoretical Similarities of Rayleigh and Lamb Modes of Vibration

L.E. Pitts, T.J. Plona and W.G. Mayer

Dept. of Physics, Georgetown Univ., Washington, D.C. 20007, J. Acoust. Soc. Amer., 60 (2), pp 374-377 (Aug 1976) 7 figs, 9 refs

Key Words: Rayleigh waves, Lamb waves, Normal modes, Plates, Half space

Poles of the infinite plane-wave reflection coefficient are used to show a correspondence between Rayleigh and Lamb modes of vibration. It is demonstrated that a Rayleigh vibrational mode is a special type of Lamb mode of vibration. Further, it is shown that it should be expected that one vibrational mode for a thick plate should be similar to the theoretically predicted vibrational mode of an infinite half space, a Rayleigh mode. Thus, it is consistent to use a thick plate as an approximation to an infinite half space and expect results predicted by Rayleigh-wave analysis.

77-8

Mathematical Programming Methods for Displacement Bounds in Elasto-Plastic Dynamics

L. Corradi

Center M.C.S., Dept. of Structural Engrg., Politecnico di Milano, I-20133 Milano, Italy, Nucl. Engr. Des., 37 (1), pp 161-177 (Apr 1976) 8 figs, 25 refs

Key Words: Mathematical programming, Shakedown theorem

In this paper a study of several deformation bounding techniques is performed. The problem is formulated and the main previous results are outlined first with reference to general continua made of hardening materials. A class of discrete structural models (such as some finite element discretizations) is considered and, on this basis, two categories of deformation bounding techniques are described from the previous main results. All these techniques, some of which are new, permit the optimization of the upper bound by solving one or more mathematical programming problems of special forms. Some of the bounding procedures are shown to have merely theoretical interest, since they lead to cumbersome numerical procedures or to very coarse bounds. The formulations that appear to have practical application are compared from various standpoints (type of loading history, different hardening rules, influence of second order geometric effects, quantities to be bounded) and a first assessment of their practical usefulness is attempted.

77-9

Extremum Principles in the Dynamics of Rigid-Plastic Bodies: A Critical Review of Existing Applications

T. Wierzbicki

Polish Academy of Sciences, Inst. of Fundamental Technological Research, 00-049 Warsaw, Poland, Nucl. Engr. Des., 37 (1), pp 149-160 (Apr 1976) 21 refs

Key Words: Extremum principles, Dynamic structural analysis

This article discusses some of the limitations and clarifies difficulties in applying the extremum principles to dynamic problems for rigid-plastic continua and structures with special reference to the development of analytical methods. In particular, an attempt is made to answer the following questions: (1) To what extent the existing methods can be used in the analysis of transient problems for impulsively or pulse loaded structures? (2) Under what conditions stationarity of appropriate functionals can be proved so that use of direct methods of the calculus of variations is well legitimated? (3) Can a formal approximation method be developed for mode form response in which exact solution is approached with any desired degree of accuracy?

NONLINEAR ANALYSIS

77-10

Subharmonic and Superharmonic Synchronization in Weakly Non-Linear Systems

R.N. Tiwari and R. Subramanian

Dept. of Electrical Engrg., Indian Inst. of Tech., Kanpur-208016, India, J. Sound Vib., 47 (4), pp 501-508 (1976) 2 figs, 8 refs

Key Words: Nonlinear systems, Resonant response

This paper deals with the necessary conditions required for subharmonic and superharmonic synchronization in weakly non-linear systems with multiple inputs. For a second order system with a given non-linearity all possible subharmonic, superharmonic and ultrasubharmonic synchronizations are determined. An example is furnished which illustrates the kind of possible synchronization.

NUMERICAL ANALYSIS

(Also see Nos. 37, 75, 81)

77-11

Numerical Method for Determination of the Stability of Linear Systems with Periodic Coefficients

Y. Narkis and M.J. Cohen

Dept. of Aeronautical Engrg., Technion - Israel Inst. of Technology, Haifa, Israel, J. Sound Vib., 47 (4), pp 571-575 (1976) 3 figs, 5 refs

Key Words: Linear systems, Stability analysis, Numerical analysis

A general method is presented for computing the characteristic multipliers of a linear system of order n with period coefficients, by integrating it over n periods. The calculation of the multipliers in this method is very simple, and in the special case of a reciprocal system the required numerical integration is reduced considerably, in comparison to other solution procedures. An example is given for a third-order system.

OPTIMIZATION TECHNIQUES

77-12

Optimization of Distributed Parameter Structures Under Dynamic Loads

T.T. Feng, E.J. Haug, Jr. and J.S. Arora

Intertech Corp., Iowa City, IA., Rept. No. 25, 40 pp (June 1976)

AD-A025 368/2GA

Key Words: Optimization, Steepest descent method, Cantilever beams, Beams, Plates

In this report, optimal design of continuous structural systems under dynamic loads is considered. An optimization technique is developed based on the generalized steepest descent method and optimal control techniques of Bryson and Ho. The method is then applied to some beam and plate problems.

PERTURBATION METHODS

77-13

The Maslov-WKB Method for the (an-)Harmonic Oscillator

J.P. Eckmann and R. Seneor

Dept. de Physique Theorique, Universite de Geneve, Geneve, France, Archive Rational Mech. Anal., 61 (2), pp 153-173 (Oct 6, 1976) 3 figs, 3 refs

Key Words: Oscillators, Perturbation theory, Asymptotic approximations

This paper attempts to present Maslov's method on asymptotic perturbations at an elementary level. The harmonic oscillator in one dimension is utilized.

STABILITY ANALYSIS

77-14

Stiffly Stable Methods for Undamped Second Order Equations of Motion

P.S. Jensen

Palo Alto Research Lab., Structural Mechanics Lab., Palo Alto, CA 94304, SIAM J. Numer. Anal., 13 (4), pp 549-563 (Sept 1976) 7 figs, 6 refs

Key Words: Stability analysis, Equations of motion

This paper presents third order linear multistep formulas which can be utilized for obtaining stable solutions for an undamped equation of motion.

77-15

Stability Theory for Systems of Inequalities. Part II: Differentiable Nonlinear Systems

S.M. Robinson

Mathematics Research Center, Univ. of Wisconsin - Madison, Madison, WI 53706, SIAM J. Numer. Anal., 13 (4), pp 497-513 (Sept 1976) 17 refs

Key Words: Stability analysis

This paper develops a condition for stability of the solution set of a system of nonlinear inequalities over a closed convex set in a Banach space, when the functions defining the inequalities are subjected to small perturbations. The condition involves the linearization of the system about a point; it is shown to be sufficient and, under a weak additional hypothesis, also necessary for stability. Quantitative estimates for the changes in the solution set are obtained.

STATISTICAL METHODS

(See No. 31)

FINITE ELEMENT MODELING

(See Nos. 88, 89, 96, 136)

MODELING

(See Nos. 193, 200)

DESIGN INFORMATION

(See Nos. 35, 135, 175, 188)

DESIGN TECHNIQUES

(See No. 185)

CRITERIA, STANDARDS, AND SPECIFICATIONS

(See Nos. 161, 217)

MODE SYNTHESIS

77-16

Mode Synthesis Technique for Dynamic Analysis of Structures

B.N. Agrawal

COMSAT Laboratories, Clarksburg, MD 20734, J. Acoust. Soc. Amer., 59 (6), pp 1329-1338 (June 1976) 2 figs, 9 refs

Sponsored by International Telecomm. Satellite Organization

Key Words: Cantilever beams, Dynamic structural analysis, Normal modes, Natural frequencies, Computer programs

A mode synthesis technique is presented for determining the normal modes, natural frequencies, and response of three-dimensional complex structure with flexible joints. Lagrange's equations are used to develop the equations of motion of the structures. Based on this technique a computer program called MODSYN has been developed for both free-free and cantilever systems. An example demonstrates the accuracy of this method.

77-17

Modal Truncation of Substructures Used in Free Vibration Analysis

S.K. Tolani and R.D. Rocke

Structural Dynamics Research Corp., Cincinnati, OH., J. Engr. Indus., Trans. ASME, 98 (3), pp 827-834 (Aug 1976 12 figs, 15 refs

Key Words: Modal analysis, Beams

A unified approach to a group of structural dynamics analyses using the substructures technique and a consistent basis for the selection of substructure principal modes as required by this method are provided. Substructure frequency roots and strain energy in the principal modes are two criteria evaluated for the selection of substructure principal modes. Based on a simple example of a cantilever beam, it is noted that the substructure principal mode strain energy criterion provides slightly better results in terms of system eigenvalues and system strain energy in the principal modes. Errors in system eigenvalues and principal mode strain energy converge nonmonotonically as the number of substructure modes retained is increased. Since in actuality, these errors are not known, expressions for their estimates are presented. It is seen that modal truncation errors in system strain energy can be better estimated in comparison to the system eigenvalue errors.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 25, 36, 123, 138, 150, 197, 226)

77-18

Vibration and Instability of Plate-Assemblies Including Shear and Anisotropy (VIPASA) User's Guide, Addendum

M.S. Anderson, K.W. Hennessy and W.L. Heard

Langley Research Center, NASA, Langley Station, VA., Rept. No. NASA-TM-X-73914, 50 pp (May 1976)

N76-26582

Key Words: Computer programs, Plates, Stability analysis, Vibration response

Extensions to the VIPASA computer program are described including a procedure for simple thermal stress analysis and options for graphical display of output. Input requirements for operation of the modified program are given in detail.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 45, 47, 66, 98, 102, 131, 156, 157, 167, 182, 187, 200, 202, 204, 205, 206, 212, 215, 227)

77-19

Mathematical Formulation for the Propagation of Sound Through a Turbulent Jet

M. Gunzburger, C.H. Liu, L. Maestrello and L. Ting

ICASE-NASA Langley Research Center, Hampton, VA., J. Engr. Math., 10 (3), pp 219-230 (July 1976) 9 refs

Key Words: Sound propagation

The sound propagation through a nonuniform turbulent jet flow field is studied by means of a system of linearized equations governing the acoustic variables. These equations depend on the fluctuating flow-field variables which can be prescribed by experimental results. It is shown that the correlations of the acoustic variables depend throughout the flow field on the space-time correlation of the turbulent velocities and on the mean flow variables and their gradients.

77-20

Vortex-Shedding Noise from Oscillating Cylinders

T.E. Burton and R.D. Blevins

General Atomic Co., San Diego, CA 92138, J. Acoust. Soc. Amer., 60 (3), pp 599-606 (Sept 1976) 6 figs, 10 refs

Key Words: Cylinders, Noise generation, Vortex shedding

The theory of sound radiation from cylinders vibrating in resonance with vortex shedding is extended to consider the effects of vibration amplitude and mode shape. Farfield intensity and total radiated power are expressed as functions of given structural and flow parameters. Closed form solutions for intensity are obtained when cylinder vibration velocity is either much smaller than or comparable to mean flow velocity.

77-21

Relationship Between Acoustic Reflection and Vibrational Modes of Elastic Spheres

R.H. Vogt and W.G. Neubauer

Naval Research Lab., Washington, D.C., J. Acoust. Soc. Amer., 60 (1), pp 15-22 (July 1976) 11 figs, 10 refs

Key Words: Acoustic scattering, Spheres, Underwater sound

The behavior of the solution to acoustic backscattering by elastic spheres in water is examined. Specific free modes of vibration are identified with significant changes in form function. The solution for spheres of tungsten carbide, aluminum, and brass are considered. Minima in the form function usually occur at or near frequencies at which sphere resonances occur. Form functions are examined which are computed from mixing rigid and elastic terms in the wave-harmonic series. In this way it is possible to see the effect of an isolated mode of vibration on the form function that describes the backscattering. Calculated resonance widths as well as observed pulse decay times allow determination of analytical and experimental damping associated isolated resonances.

77-22

Recent Results of Absolute Sound Velocity Measurements in Pure Water and Sea Water at Atmospheric Pressure

W. Kroebel and K.H. Mahrt

Institute of Applied Physics, University Kiel, D-23 Kiel, Germany, Acustica, 35 (3), pp 154-163 (June 1976) 10 figs, 15 refs

Key Words: Sound transmission, Water

High precision absolute sound velocity measurements in pure water and natural sea water at different temperatures and at atmospheric pressure have been made, using an ultrasound oscillator method with continuous waves. A relatively long sound path of up to about 84 cm was used in order to obtain propagation conditions which differ more from those of other comparable methods of high precision sound velocity measurements.

77-23

Noise Path Diagnostics in Dispersive Structural Systems Using Crosscorrelation Analysis

J.E. Barger

Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, Noise Control Engr., 6 (3), pp 122-137 (May-June 1976) 3 figs, 7 refs

Key Words: Noise path diagnostics, Crosscorrelation technique

A common problem faced by the noise control engineer is the identification of the dominant paths from a known noise source in a structural system to a receiver location on or near the structural system. In this paper, the analysis of broadband noise propagating over arbitrarily long paths in a general dispersive medium is discussed and illustrated. The diagnostic procedure for shipboard noise control is shown.

77-24

Noise Measurements for a Twin-Engine Commercial Jet Aircraft During 3 Deg Approaches and Level Flyovers

E.C. Hastings, Jr., R.E. Shanks and A.W. Mueller

Langley Research Center, NASA, Langley Station, VA., Rept. No. NASA-TM-X-3387; L-10780, 60 pp (July 1976)

N76-26950

Key Words: Aircraft noise, Noise measurement

Noise measurements from a twin-engine commercial jet aircraft making 3 deg approaches and level flyovers are reported.

77-25

A New Capability for Predicting Helicopter Rotor Noise in Hover and in Flight

T.J. Brown and F. Farassat

Army Air Mobility Research and Development Lab., Langley Directorate, Hampton, VA.

AD-A025 982/0GA

Key Words: Aircraft noise, Helicopter noise, Propeller noise, Noise prediction, Computer programs

This paper discusses a new theory and a computer program for calculation of acoustic pressure signature and spectrum of rotor and propeller noise. Many of the common restrictions of already existing theories are removed by using the new theory which is consistent with all previous theories.

77-26

TTS From Neighborhood Aircraft Noise

W.D. Ward, W.M. Cushing and E.M. Burns

Hearing Research Lab., Univ. of Minnesota, Minneapolis, MN., J. Acoust. Soc. Amer., 60 (1), pp 182-185 (July 1976) 1 fig, 12 refs

Sponsored by the National Inst. of Occupational Safety and Health

Key Words: Aircraft noise, Human response

In an attempt to determine the effect on the auditory threshold of the worst "neighborhood" exposure to aircraft noise that can reasonably be expected, tape-recorded overpasses, both landings and takeoffs, were reproduced. Six-hour exposures to landings or takeoffs were given to one of two groups of five normal listeners. The mean TTS_2 (temporary threshold shift 2 min after exposure) did not reach 5 dB at any frequency in any condition.

77-27

In-Flight Far-Field Measurement of Helicopter Impulsive Noise

D.A. Boxwell and F.H. Schmitz

Army Air Mobility Research and Development Lab., Moffett Field, CA., 15 pp (1976)

AD-A025 979/6GA

Key Words: Helicopter noise, Aircraft noise, Noise measurement

An in-flight technique for measuring UH-1H helicopter impulsive noise by stationkeeping with an instrumented lead aircraft is described.

77-28

Characteristics of Several Industrial Noise Environments

L.H. Royster and J.E. Stephenson

Center for Acoustical Studies, North Carolina State Univ., Raleigh, NC 27607, J. Sound Vib., 47 (3), pp 313-322 (Aug 8, 1976) 17 figs, 9 refs

Key Words: Industrial facilities, Noise generation

In order to further define the characteristics for different noise environments existing in industry over 2000 work stations in eleven different industries were investigated. The data measured included dB(A) sound levels and octave band sound pressure levels. These data are analyzed with respect to mean slope, mean slope as related to dB(A) sound level, flatness, bands of concentrated acoustic energy (or pure tones) and the correlation between the measured dB(A) sound level and that predicted by using the measured octave band sound pressure levels.

77-29

Diffraction of Sound by a Rigid Screen with an Absorbent Edge

A.D. Rawlins

Dept. of Mathematics, Univ. of Dundee, Dundee DD1 4HN, Scotland, J. Sound Vib., 47 (4), pp 523-541 (1976) 11 figs, 9 refs

Key Words: Noise barriers, Mathematical models, Acoustic linings

A solution is obtained for the problem of diffraction of a plane wave sound source by a semi-infinite plane. A finite region in the vicinity of the edge has an impedance boundary condition; the remaining part of the half plane is rigid. The problem which is solved is a mathematical model for a rigid barrier with an absorbing edge.

77-30

Acoustic Systems Containing Curved Duct Sections

W. Rostafinski

NASA, Lewis Research Center, Cleveland, OH., J. Acoust. Soc. Amer., 60 (1), pp 23-28 (July 1976) 7 figs, 8 refs

Key Words: Ducts, Curved pipes, Acoustic impedance

The analysis of waves in bends in acoustical ducting of rectangular cross section is extended. This includes determination of the characteristics of the tangential and radial components of the nonpropagating modes. It is established that attenuation of the nonpropagating modes strongly depends on frequency and that, in general, the sharper the bend, the less attenuation may be expected. Evaluation of a bend's impedance and of impedance generated reflections is also presented in detail.

77-31

A Procedure for the Statistical Analysis of Vehicular Noise Emission Spectra for Limited Samples

R.N. Brooke

Army Tank-Automotive Systems Development Ctr., Warren, MI., Rept. for Apr 1973 - Mar 1974, 11 pp (1976)

AD-A025 981/2GA

Key Words: Traffic noise, Statistical analysis

Recent emphasis on the reduction of environmental pollution has prompted the legislation of many new standards defining maximum noise limits inside of, and in close proximity to all types of commercial and military automotive vehicles. These standards require the collection of noise emission data on both newly produced and inservice vehicles for determination of conformance. Since every vehicle to be produced or currently in existence that falls within the jurisdiction of the standards cannot be measured individually due to time and cost constraints, a method of accurately predicting the noise profile of a large population of similar type vehicles utilizing data collected from only a limited sample of the population is required. This paper presents such a statistical method, and illustrates its application utilizing data taken on multiple samples of several types of military tactical vehicles.

77-32

Environmental Noise Measurements on Interstate 57 During and After Truck Strike

P.D. Schomer and B.L. Homans

Construction Engineering Research Lab. (Army), Champaign, IL., Rept. No. EPA/550/9-74/010, 71 pp (June 1974)

PB-253 198/6GA

Key Words: Trucks, Noise measurement

Noise and traffic-count data were recorded and analyzed during and immediately after a nationwide strike of independent truckers. This report presents statistical noise levels, equivalent sound level and day-night level for a two-week data-gathering period. From these results it is possible to infer the truck contribution to highway noise.

77-33

Transmission and Reflection of Rayleigh Waves by a High Impedance Obstacle of Finite Length

T. Yoneyama and S. Nishida

Research Inst. of Electrical Communications, Tohoku Univ., Sendai 980, Japan, J. Acoust. Soc. Amer., 60 (1), pp 90-94 (July 1976) 4 figs, 7 refs

Key Words: Acoustic impedance, Rayleigh waves, Wave reflection

A new method is presented for calculating the transmission and reflection coefficients of Rayleigh waves by a high impedance obstacle of finite length. The problem is formulated in terms of simultaneous integral equations which can be solved by a kind of iterative procedure.

77-34

Propagation of a Spherical Wave Near a Plane Boundary with a Complex Impedance

R.J. Donato

Div. of Physics, National Res. Council of Canada, Ottawa, Canada, J. Acoust. Soc. Amer., 60 (1), pp 34-39 (July 1976) 4 figs, 7 refs

Key Words: Spherical waves, Sound waves, Acoustic impedance

An analysis, using complex angles of incidence as the variable in a steepest descents integration, is made of the propagation of sound from a point source over a locally reacting complex impedance boundary. The integration process contains more terms than are normally used in the analysis, and the solution is valid over a large range of horizontal distances. Conditions for the existence of surface waves are discussed in some detail. A comparison is made of measured and calculated values of pressure on the boundary.

RANDOM

(See Nos. 168, 224)

SEISMIC

(Also see Nos. 135, 171, 175, 194, 229)

77-35

A Study of Earthquake Response Spectra for Different Geological Conditions

B. Mohraz
Civil and Mechanical Engrg. Dept., Inst. of Tech., Southern Methodist Univ., Dallas, TX 75275, Bull. Seismol. Soc. Amer., 66 (3), pp 915-935 (June 1976) 10 figs, 26 refs

Key Words: Seismic design, Earthquakes

This study examines the effects of geological conditions on the response spectra and the ground-motion parameters such as peak ground acceleration, velocity, and displacement. Design spectra are presented for various sites such as alluvium deposits, rock deposits, and alluvium layers underlain by rock deposits.

77-36

On the Incorporation of Damping in Large, General-Purpose Computer Programs

F.C. Nelson and R. Greif
Dept. of Mechanical Engrg., College of Engineering, Tufts Univ., Medford, MA 02155, Nucl. Engr. Des., 37 (1), pp 65-72 (Apr 1976) 27 refs

Key Words: Earthquake damage, Structural response, Equipment response, Damping, Computer programs

Damping plays an important role in the dynamic response of structures and equipment subjected to broadband excitation such as that due to earthquake. Its incorporation into general-purpose shock and vibration computer programs has been based on either a concern for the physical mechanisms of damping or on the need for mathematical convenience. The more physical approach starts with the equation of motion which is derived from element properties in a manner consistent with the derivation of stiffness. Expressions for a consistent damping matrix exist for radiation of energy by travelling waves, fluid flow damping and internal energy dissipation by the material. Under certain conditions, it is convenient to incorporate the material damping as a complex stiffness. The equation of motion can then be rewritten in a symmetric form. The equations can be uncoupled by the damped, complex eigenvalues and solved by modal superposition.

SHOCK

(Also see Nos. 130, 170, 196, 208, 214)

77-37

Dynamic Analysis of Impact Attenuation Systems Utilizing Plastic Deformations

K. Ohmata and H. Fukuda
Dept. of Engineering, Meiji Univ., Ikuta, Tama-ku, Kawasaki, Japan, Bull. JSME, 19 (132), pp 584-589 (June 1976) 9 figs, 1 ref

Key Words: Dynamic response, Shock abosrbers, Beams, Simulation, Successive approximation method

A structure whose load-displacement curve due to geometry change after initial yield is expressed approximately by a cubic nonlinear curve is represented by a dynamically equivalent system consisting of a nonlinear spring and a slider, and its dynamic response to the impact of a moving mass is analyzed by means of successive approximation. This analysis is carried out with a structure made of a rigid-perfectly-plastic material, but the results are applicable to the case of an elastic-perfectly-plastic material. Numerical examples are given for a U type beam subjected to an impulsive loading at the tip.

77-38

Peak Load - Impulse Characterization of Critical Pulse Loads in Structural Dynamics

G.R. Abrahamson and H.E. Lindberg
Stanford Research Institute, Menlo Park, CA 94025, Nucl. Engr. Des., 37 (1), pp 35-46 (Apr 1976) 15 figs, 12 refs
Sponsored by AF Weapons Lab., AF Space & Missiles Org., and Defense Nuclear Agency

Key Words: Dynamic structural analysis, Pulse excitation, Beams, Plates, Shells

The P-I characterization scheme greatly facilitates specification of critical loads for structures subjected to air blast loading and is generally useful for structures subjected to pulse loads. A general feature of the P-I characterization scheme is that critical load curves are represented reasonably well by a rectangular hyperbola.

GENERAL WEAPON

(See No. 139)

PHENOMENOLOGY

COMPOSITE

(Also see Nos. 111, 127)

77-39

An Evaluation of the Shelter Panel Inspector as a Nondestructive Device to Test Army Shelter Panels for Structural Integrity

T.E. Smith

Darcom Intern Training Center, Texarkana, TX., Rept. No. DARCOM-ITC-02-08-76-112, 37 pp (May 1976)

AD-A025 908/5GA

Key Words: Panels, Sandwich structures, Honeycomb structures, Nondestructive testing

This research evaluates the Shelter Panel Inspector as a nondestructive device to test Army shelter panels for structural integrity.

77-40

A Study of Wave Motion in Fiber-Reinforced Medium

C.H. Yew and P.N. Jogi

Dept. of Aerospace Engrg. and Engrg. Mechanics, Univ. of Texas at Austin, Austin, TX 78712, Intl. J. Solids Struc., 12 (9/10), pp 693-703 (1976) 8 figs, 20 refs

Key Words: Fiber composites, Wave propagation

Measurements, both macroscopic and microscopic, of longitudinal wave motions propagating in the direction of reinforcing fibers were made on laboratory fabricated fiber-reinforced composites. Two waves with different propagation speeds and amplitudes were observed. Results are in good agreement with the predictions based on the mixture theory and the effective stiffness theory.

DAMPING

(Also see Nos. 36, 69, 142, 224)

77-41

Analysis of Equations of Motion with Complex Stiffness Mode Superposition Method Applied to Systems with Many Degrees of Freedom

Y. Tsushima, J. Jido and N. Mizuno

Takenaka Technical Research Lab., Takenaka Komuten Co., Koto-ku, Tokyo, Japan, Nucl. Engr. Des., 37 (1), pp 47-64 (Apr 1976) 7 figs, 64 refs

Key Words: Equations of motion, Structural members, Damping

According to past experimental studies, the damping effects of a structure may be considered to be elastic. In this paper, the authors propose a simple method of expressing the abovementioned damping effects using complex numbers, even though viscous damping mechanics is generally used as the conventional mathematical method. The concept of complex damping is described comparing it with the most common "Voigt model" for a system with a single degree of freedom and it is concluded that both solutions are exactly identical under the conditions of free and forced vibration when both systems have equivalent natural periods and damping ratios. Furthermore, the authors attempt to apply the above complex stiffness to multi systems with many degrees of freedom and investigate their mathematical and dynamical characteristics.

ELASTIC

77-42

The Existence of Pure Surface Modes in Elastic Materials with Orthorhombic Symmetry

P. Chadwick

School of Mathematics and Physics, Univ. of East Anglia, Norwich, England, J. Sound Vib., 47 (1), pp 39-52 (July 8, 1976) 2 figs, 23 refs

Key Words: Wave propagation, Harmonic waves, Rayleigh waves, Elastic media

A pure surface mode in a semi-infinite elastic body with a traction-free boundary is a progressive harmonic surface wave in which the displacement is everywhere co-planar with the wave and surface normals. When the elastic material has orthorhombic symmetry, with one of the 2-fold symmetry axes normal to the bounding plane, there are generally only two directions in which a pure surface mode may propagate, but additional directions appear when the transmitting material has higher symmetry.

FLUID

(Also see Nos. 20, 22, 108, 125, 165, 229)

77-43

Multiple Internal Resonance in a Structure-Liquid System

R.A. Ibrahim
Dept. of Mech. Engrg., Univ. of Edinburgh, Edinburgh, Scotland, J. Engr. Indus., Trans. ASME, 98 (3), pp 1092-1097 (Aug 1976) 8 figs, 26 refs

Key Words: Sloshing, Fluid-filled containers, Resonant response

The autoparametric coupling of a vibrating structure with liquid sloshing modes is demonstrated by means of a system consisting of a two degree of freedom structure carrying a rigid container partially filled with liquid. When the system is subjected to vertical excitation the liquid container oscillates up and down and, under certain internal resonance condition, it moves laterally as well. Energy is then exchanged between the structure vibration modes and the liquid sloshing modes. Nonlinear inertia terms in the equations of motion predominate in the behavior of the system undergoing autoparametric resonance. For two simultaneous internal resonance relations and external resonance near one of the frequencies involved in the internal resonance relations, the system performance is investigated theoretically and experimentally. The system shows unsteadiness and instability for most of the conditions considered, and these unstable motions are demonstrated in the experimental investigation. The effects described must be regarded as possible sources of structural failure in practical engineering systems.

77-44

Ray Effects in the Normal Mode Approach to Underwater Acoustics

K.M. Guthrie and C.T. Tindle
Dept. of Physics, Univ. of Auckland, Private Bag, Auckland, New Zealand, J. Sound Vib., 47 (3), pp 403-413 (Aug 8, 1976) 4 figs, 12 refs

Key Words: Underwater sound, Normal modes

The normal mode expression which describes the transmission of a pressure pulse in an underwater sound channel is examined. For a fixed source and receiver, the contribution of groups of modes with approximately the same equivalent-ray angle is shown to be large only when the angle corresponds to an angle predicted by ray theory. Thus in a many-mode situation, the exact mode expression contains a multipath structure which is the same as that found in the ray solution. However, the "physical rays" appearing in mode theory are "fuzzy" in that they have a finite width. A closed-form expression is derived for the physical rays of the isovelocity sound channel. These "rays" travel along geometric ray-paths and become arbitrarily narrow in the high frequency limit.

77-45

Acoustic Propagation in Shallow Water Overlying a Consolidated Bottom

F. Ingenito and S.N. Wolf
Naval Research Lab., Washington, D.C. 20375, J. Acoust. Soc. Amer., 60 (3), pp 611-617 (Sept 1976) 4 figs, 6 refs
Sponsored by the Naval Sea Systems Command and ONR

Key Words: Underwater sound transmission, Sound transmission

An experiment designed to measure normal mode amplitude functions and attenuation coefficients was conducted in shallow water on Campeche Bank off the Yucatan Peninsula. Measurements were made at two locations on the bank in water of about 30 m in depth over a bottom consisting of consolidated limestone having a measured and sound velocity of 1900 m/sec. Pulsed cw signals with frequencies of 400, 750, and 1500 Hz were used. Theoretical calculations of the mode amplitude functions using a fluid model of the bottom were found to agree well with the measurements. In order to reconcile the measured mode attenuation coefficients with theory, it was necessary to assume that the shear velocity of the bottom was 1000 m/sec.

77-46

Damping of Fluid Vibrations in Hydrostatic Lines

D. Hoffmann
VDI Forschungsheft No. 575, 48 pp (1976), 107 figs, 113 refs

Key Words: Hydraulic equipment, Fluid-induced excitation, Vibration damping

Vibration transfer by hydrostatic fluid contributes to noise emission of elements far away from the vibration source. This effect can be decreased by vibration dampers in the line. A single expansion chamber decreases the fluid sound in a rate of 20 dB to 40 dB and a double expansion chamber system in a rate of more than 40 dB. A hydro-pneumatic accumulator is qualified for vibration damping only by use of short connection line with large diameter. Normal flexible tubes decrease the fluid sound only in a small rate; more effective are special flexible tubes with great volumetric capacity. Interference lines are not suitable for a wide band damping.

77-47

Experimental Study on the Wave Mode in Elastic Cylindrical Rod

H. Toda, H. Fukuoka and T. Tanida

Dept. of Engrg. Science, Osaka Univ., Toyonaka, Japan, Bull. JSME, 19 (132), pp 590-594 (June 1976) 9 figs, 3 refs

Key Words: Cylindrical bodies, Elastic waves, Normal modes, Group velocity

Experimental study on the high frequency elastic wave mode propagating in a long circular aluminum rod was executed using new devices. A four terminals type piezo-electric transducer was used to observe the phase of vibration of each mode at the end of the rod and to classify directly the wave modes. Experimental results are shown.

SOIL

77-48

On the Influence of the Geometry of the Foundation on its Impulse Response

A. Umek

Civil Engrg. Dept., Univ. of Ljubljana, Ljubljana, Yugoslavia, J. Appl Mech., Trans. ASME, 43 (2), pp 300-303 (June 1976) 3 figs, 9 refs

Key Words: Foundations, Interaction: soil-structure, Geometric effects

The influence of the foundation geometry on the antiplane impulse response of an embedded foundation is the topic. The foundations of a semicircular and a rectangular cross section are selected as characteristic examples. The impulse response for the semicylindrical foundation is obtained from its admittance derived by Luco and Trifunac and is compared with the impulse response of the rectangular foundation as obtained by Thau and Umek.

VISCOELASTIC

(See No. 78)

EXPERIMENTATION

BALANCING

(See Nos. 181, 222, 223)

DIAGNOSTICS

(Also see Nos. 73, 228)

77-49

Machine Life Expectation

R.A. Collacott

Leicester Polytechnic, Great Glen, Leicestershire, England, J. Engr. Indus., Trans. ASME, 98 (3), pp 862-867 (Aug 1976) 17 figs, 8 refs

Key Words: Machinery, Diagnostic techniques

Life of a machine comprises essentially two phases, namely (a) infant mortality as initial failures due to initial weaknesses are overcome as the machine "wears in," and (b) life mortality which increases as the machine is used and the components expend their physical metallurgical cohesive strengths. Techniques of failure monitoring record these trends and the problem presents itself of providing a means of relating the condition recorded by monitoring and previous data to the future life expectancy both as a means of technologically determining the maintenance state and as a means of anticipating future life both as a means of forecasting the possibility of catastrophic failure and as a replacement philosophy based on technological redundancy. This paper presents a theory from which such conjectures may be developed.

EQUIPMENT

(Also see No. 64)

77-50

Development of Capabilities for Stall/Spin Research

A. Craig

Dept. of Aeronautical Engrg., Wichita State Univ., Wichita, KS., Rept. No. NASA-CR-148287, 42 pp (June 10, 1976)

N76-26221

Key Words: Test equipment, Testing techniques, Aircraft

Apparatus and techniques were developed for measuring in a low-speed wind tunnel the static and dynamic (rotary balance) aerodynamic data pertinent to spin behavior of a general aviation aircraft. The main results involved the collection of static force and moment data for several airplane configurations. Difficulties, shortcomings, and unsuitability of some aspects of the rotary balance mount as constructed were discovered and identified for avoidance in a new mount design.

FACILITIES

(Also see No. 62)

77-51

Noise and Flow Management in Blowdown Wind Tunnels

E.L. Whitfield

Lockheed-California Co., Burbank, CA., In: AGARD Wind Tunnel Design and Testing Tech., 7 pp (Mar 1976) (N76-25213)

N76-25219

Key Words: Wind tunnels

A 4-foot blowdown wind tunnel was designed to specifications oriented almost exclusively toward supersonic operation, with the result that flow quality at subsonic and transonic speeds was unduly compromised. Several recent tunnel modifications, designed to correct this deficiency, have resulted in a reduction of the test section pressure unsteadiness such that the present level compares favorably with that found in closed circuit, continuous wind tunnels. Experimental efforts with a 1/12-scale model tunnel, used for the purpose of establishing suitable modifications, are recounted. Model and full scale tunnel data indicate that a significant reduction in throttle valve induced noise levels can be obtained by breaking up the valve discharge flow into a large number of small jets. This approach yields low turbulence flow even with a pressure ratio across the valve as large as 30.1.

77-52

Induction Wind Tunnel Performance: Test Section Flow Quality and Noise Measurements

J. Rom, J. Braha and A. Seginer

Dept. of Aeronautical Engrg., Technion - Israel Inst. of Tech., Haifa, Israel, In: AGARD Wind Tunnel Design and Testing Tech., 8 pp (Mar 1976) (N76-25213)

N76-25218

Key Words: Wind tunnels

Flow quality measurements obtained in the 60cm x 80cm IDT are presented and discussed with particular emphasis on the noise and pressure fluctuations. Measurements of the flow uniformity in the test section, over the Mach number range of 0.4 to 1.15 obtained by the operation of a circumferential injector, are presented. Extension of the Mach number range to low supersonic Mach numbers is discussed.

77-53

High Frequency Gust Tunnel

H. Viets

Air Force Aero Propulsion Lab., Wright-Patterson AFB, OH., In: AGARD Wind Tunnel Design and Testing Tech., 8 pp (Mar 1976) (N76-25213)

N76-25242

Key Words: Test facilities, Wind tunnels

A mechanism is proposed employing unsteady fluidically controlled flapping jets for application to the production of variable frequency gusts in wind tunnels or in ambient air. The basic mechanism is an unsteady jet based on the simple fluidic element and controlled either by an acoustic feedback line between the control ports or by a pair of rotating valves simply constructed from slotted rods.

77-54

Acoustic Fluctuations Generated by the Ventilated Walls of a Transonic Wind Tunnel

X. Vaucheret

Office National d'Etudes et de Recherches Aerospatiales, Paris, France, In: AGARD Wind Tunnel Design and Testing Tech., 10 pp (Mar 1976) (N76-25213)

(In French)

N76-25237

Key Words: Wind tunnels, Noise reduction

In order to reduce the noise level due to the acoustic perturbations generated by the wall perforations in the transonic test section, a classification of the noises emitted by several ventilated panels inserted in the test section was established. For this experimentation, the horizontal perforated walls are closed with adhesive tapes covering the holes.

77-55

Design and Operation of a Low-Speed Gust Tunnel

R.A. Sawyer

Dept. of Mechanical Engrg., Salford Univ., England, In: AGARD Wind Tunnel Design and Testing Tech., 7 pp (Mar 1976) (N76-25213)

N76-25243

Key Words: Test facilities, Wind tunnels, Wind-induced excitation, Buildings, Aircraft wings

The design of a low speed gust tunnel is described. The tunnel can produce sinusoidal, random or sharp edged vertical gust distributions in a horizontal airstream.

77-56

Current Research on the Simulation of Flight Effects on the Noise Radiation of Aircraft Engines

J. Fitremann and M. Perulli

Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche, France, In: AGARD Flight/Ground Testing Fac. Correlation, 3 pp (Apr 1976) (N76-25266)

(In French)

N76-25280

Key Words: Test facilities, Acoustic tests, Anechoic chambers, Wind tunnels, Aircraft noise

Design problems related to the development of an anechoic wind tunnel were described. Typical results are presented, dealing with fundamental research on refraction, scattering and diffusion studies.

77-57

Some UK-Government Establishment Research Towards Quieter Aircraft

F.W. Armstrong and J. Williams

National Gas Turbine Establishment, Pyestock, Farnborough GU14 0LS, England, J. Sound Vib., 47 (2), pp 207-236 (July 22, 1976) 27 figs, 25 refs

Key Words: Test facilities, Aircraft, Noise reduction

This paper aims to give an impression of the scope of research programs and development of national experimental facilities directed specifically towards the evolution of economic quieter aircraft. The paper discusses major problem areas associated with the development of quieter aircraft, the particular research work required, and the related development of special facilities.

77-58

Problems of Noise Testing in Ground-Based Facilities with Forward-Speed Simulation

J. Williams

Aerodynamics Dept., Royal Aircraft Establishment, Farnborough, England, In: AGARD Flight/Ground Testing Fac. Correlation, 14 pp (Apr 1976) (N76-25266)

N76-25281

Key Words: Test facilities, Acoustic tests, Aircraft noise

An overview of the design and operational problems associated with ground-based facilities for performing noise experiments with forward-speed simulation is presented. Various facilities are described.

77-59

Development of the United Technologies Research Center Acoustic Research Tunnel and Associated Test Techniques

W.M. Foley and R.W. Paterson

United Technologies Research Center, East Hartford, CT., In: AGARD Flight/Ground Testing Fac. Correlation, 10 pp (Apr 1976) (N76-25266)

N76-25279

Key Words: Test facilities, Acoustic tests, Helicopter noise

Design and development of an acoustic research tunnel is described. Its operating experience is discussed relative to the design of new acoustic test facilities. Experimental noise research programs conducted in the tunnel are described with attention given to the correlation of model studies with full-scale engine and helicopter rotor noise.

77-60

A Test Facility for Aircraft Jet Noise Reduction. Part I.

B.L. McGehee

Boeing Commercial Airplane, Co., Seattle, WA., J. Environ. Sci., 76 (4), pp 19-25 (July/Aug 1976) 17 figs, 24 refs

Key Words: Test facilities, Aircraft noise, Noise reduction

An environmental facility known to Boeing as their "Large Test Chamber" (LTC) was developed as the basic tool needed for advancing technology in jet aircraft noise reduction. A variety of jet aircraft nozzle and chamber configurations were model-tested to ensure that facility design goals would satisfy the needs for current and future aircraft. Test data accurate to ±1 dB of free-field was a facility objective.

77-61
Experimentation and Analysis to Perfect a Shock Perturbation Technique
H.N. Powell
Wisconsin Univ., Madison, WI., Rept. No. RIA-R-CR-76-014, 32 pp (Apr 1976)
AD-A025 351/8GA

Key Words: Shock tubes, Design techniques, Perturbation theory

The overall design of a shock tube has been validated with an extraordinary level of performance. It has been demonstrated that shock Mach numbers up to M* = 12 can be predicted.

SCALING AND MODELING
(See No. 144)

TECHNIQUES
(Also see Nos. 50, 106)

77-62
Research on Aircraft Noise: Test Methods
G. Casandjian
Kanner (Leo) Associates, Redwood City, CA., Rept. No. NASA-TT-F-17090, 20 pp (June 1976) (Engl. transl. from "La Rech. sur le bruit des avions - Methodes et Moyens d'essais", Assoc. Aeronaut. et Astronaut. de France. Congres intern, astronaut, 12th France (Paris), 29-30 Nov 1975, 18 pp)
N76-25166

Key Words: Testing techniques, Test facilities, Aircraft noise, Noise reduction

Methods and facilities for measuring the basic types of aircraft noise-aerodynamic engine and duct noise - are described. Various techniques for reducing noise are considered, with emphasis on the development of absorber materials and jet noise silencers. Methods for making fixed point engine noise measurements are examined, as well as noise tests on turbine rotors. Tables listing the test facility, type of test, noise performance, and sponsoring organization are presented.

77-63
Gas Turbine Transient Operating Conditions Due to an External Blast Wave Impulse
D. Dini, A. DiGiorgio and S. Cardia
Centro Applicazioni Militari dell'Energia Nucleare, Pisa, Italy, In: AGARD Unsteady Phenomena in Turbomachinery, 22 pp (Apr 1976) (N76-25169)
N76-25182

Key Words: Testing techniques, Gas turbines, Sonic boom, Simulation

The aerodynamic response of an aero gas turbine to time variant total pressure inlet distortion is considered as sonic boom signature from a supersonic aircraft or air blast wave overpressure. Various methods which have been developed for simulating sonic bangs are briefly described, and in particular the experimental work in progress for generation of strong shock wave signatures to simulate the effects on a turbojet engine in flight. Mass flow in aero gas turbine engines and unsteady measurements are considered. Prediction of the steady state performance is extended to include transient behavior. Propulsion system instability caused by inlet flow, distorted as consequence of strong shock waves, as well as possible responses of axial flow fan and compressor components are discussed in view of experimental correlation.

77-64
Alternative Test Method for Evaluating Impact Noise
T.J. Schultz
Bolt Beranek and Newman, Inc., Cambridge, MA., 02138, J. Acoust. Soc. Amer., 60 (3), pp 645-655 (Sept 1976) 8 figs, 35 refs

Key Words: Testing techniques, Test equipment, Noise measurement, Rooms, Floors, Ceilings

The current method of measuring impact noise transmission involves the use of a standard hammer machine to produce a series of impact on the floor-ceiling structure, and the measurement of the resulting noise produced in the room below. The method has been criticized on the ground that ratings based on the test data correlate poorly with the subjective judgments of people listening to real-life impacts on the same floors. An alternative test method is proposed that uses a modified hammer machine whose internal impedance, intensity of impact, and striking frequency simulate those of real footfalls. The new method involves several changes from the present standard: short-term rms impact sound levels are measured instead of long-term rms levels; no normalization for the sound absorption of the receiving room is required; since the short-term levels are higher than the long-term levels usually measured, background noise is less of a problem than for the existing method.

77-65

Light-Scattering Heterodyne Interferometer for Vibration Measurements in Auditory Organs

P.R. Dragsten, W.W. Webb, J.A. Paton and R.R. Capranica

School of Applied and Engineering Physics, Cornell Univ., Ithaca, NY 14853, J. Acoust. Soc. Amer., 60 (3), pp 665-671 (Sept 1976) 7 figs, 24 refs

Sponsored by the National Science Foundation and the National Institute of Health

Key Words: Vibration measurement, Measurement techniques, Ears

An interferometric optical heterodyne technique has been developed especially for vibrational amplitude and phase measurements on auditory organs of live animals. Laser light diffusely scattered from the vibrating structure is used for the measurement. Continuous calibration and feedback compensation systems were developed to cope with the problems of drift in interferometer alignment and small background movements.

77-66

Optical Holography for the Study of Sound Radiation From Vibrating Surfaces

C.H. Hansen and D.A. Bies

Dept. of Mech. Engrg., Univ. of Adelaide, Adelaide, South Australia 5001, J. Acoust. Soc. Amer., 60 (3), pp 543-555 (Sept 1976) 16 figs, 24 refs

Key Words: Holographic techniques, Sound generation, Vibrating structures, Plates

Time-averaged holography has been used to quantitatively investigate sound radiation from an edge-clamped circular flat plate mounted in an infinite rigid baffle. For a particular mode of vibration, the plate response is measured using holography and the sound power radiated is measured in a reverberant room with the plate mounted in one of the room walls. From these measurements a radiation efficiency is determined. The theoretical plate response is calculated using both classical and Mindlin-Timoshenko plate theory and is shown to agree well with experimental measurements. Radiated sound power is calculated for each mode of interest by solving the wave equation in oblate spheroidal coordinates at the plate surface. These calculations are verified by direct evaluation of the Rayleigh integral in the farfield. Good agreement is obtained between experimentally measured radiation efficiencies and theoretical predictions. Small discrepancies between theory and experiment are discussed.

77-67

Recent Advances in Techniques for Dynamic Stability Testing at NAE

O. Rueckemann

Unsteady Aerodynamics Lab., National Aeronautical Establishment, Ottawa, Ontario, Canada, In: Natl. Res. Council of Canada Quart. Bull. of the Div. of Mech. Eng. and the Natl. Aeron. Estab., pp 1-22 (Mar 31, 1976) (presented at Symp. on Unsteady Aerodyn., Ariz. Univ., Tucson, Mar 1975) (N76-26506)

N76-26507

Key Words: Testing techniques, Dynamic stability

Several new experimental techniques developed over the past few years include: dynamic half model experiments at moderate angles of attack, dynamic interference experiments with two oscillating models, oscillatory experiments on models with simulated exhaust plume, dynamic cross coupling experiments and vertical acceleration experiments. In each case a brief description is given accompanied by a discussion of the rationale behind the development of the technique and an indication of its potential applications.

77-68

Static Vibration Tests for Resolving Aeroelastic Problems of V/STOL Rotary Wing Aircraft

F. Kiessling

Inst. f. Aeroelastik, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Goettingen, West Germany In: DGLR Contrib. to Helicopter Technol., pp 105-130 (Nov 1975) (N76-24209) (In German)

N76-24212

Key Words: Aircraft, Vibration tests, Testing techniques

Proposals are made for static vibration testing methods of V/STOL rotary wing aircraft. A static vibration test was used to determine self vibration forms of a weakly damped elastic structure with the associated modal characteristics. The principles of this test are detailed, accentuating a phase resonance method. For V/STOL rotary wing aircraft, the rotation of the elastic rotors provokes additional effects such as gyroscopic coupling and variations of the blade stiffness by centrifugal forces. Proposals are based on these concepts. Correction terms are given for the effects of the rotating parts, which can be calculated from test results of nonrotating rotors.

77-69

Automated Resonance-Bar Damping Measurement System

A. Klimasara, N.F. Fiore, G.C. Kuczynski and D.W. Schutt

Dept. of Metallurgical Engrg. and Materials Science, Univ. of Notre Dame, Notre Dame, IN 46556, Rev. Sci. Instr., 47 (9), pp 1163-1168 (Sept 1976) 4 figs, 4 refs

Sponsored by the National Science Foundation

Key Words: Resonance bar technique, Measurement techniques, Damping

This paper describes an automated internal friction measurement system which allows continuous resonant-frequency tracking and continuous recording of damping and resonant frequency during resonance-bar internal friction experiments. A phase-locked loop based on a phase detector maintains the system at resonant frequency although the frequency may change during the course of an experiment. A modified White cathode follower is used to overcome capacitive loading effects in coaxial cables between the damping system and electronic controlling-recording components. In this manner, monitoring and recording components may be located at distances of tens of meters from the drive-detector-specimen damping system, which may in turn be located in some hostile environment of interest. The automated system may be used with damping measurement systems which employ piezoelectric, electromagnetic, or electrostatic drive-detection transducers.

77-70

Application of the Correlation Technique in Acoustics and Vibration Engineering

I. Veit

Battelle-Institut e. V., Frankfurt/Main, Germany, Acustica, 35 (4), pp 219-231 (1976) 10 figs, 52 refs

Key Words: Correlation techniques, Measurement techniques

The correlation technique can be of great value in the solution of acoustical and vibration engineering problems. After a survey of the theoretical principles, with special emphasis on the correlation function, the correlation spectrum and the cepstrum, the possibilities of applying correlation measuring techniques in acoustics and vibration engineering are discussed by means of several practical examples.

COMPONENTS

SHAFTS

(Also see No. 180)

77-71

Transient Torsional Vibration of Steam Turbine and Generator Shafts Due to High Speed Reclosing of Electric Power Lines

A. Hizume

Engrg. Dept., Utility Power Systems, Mitsubishi Heavy Industries, Ltd., Marunouchi, Chiyodaku, Tokyo, Japan, J. Engr. Indus., Trans. ASME, 98 (3), pp 968-979 (Aug 1976) 9 figs, 3 refs

Key Words: Shafts, Steam turbines, Transient response, Torsional vibration, Modal analysis, Computer programs

Transient torsional vibration induced on modern large turbine and generator shafts by high-speed reclosing is investigated qualitatively and quantitatively, assuming linearity and no damping as the first approximation. The effect of repeated impositions is analyzed both for sinusoidal torque fluctuation and for stepwise torque fluctuation.

BEAMS, STRINGS, RODS

(Also see Nos. 1, 12, 17, 37, 38, 90, 92, 141, 190, 214, 225)

77-72

Study on the Stability of the Laval Shaft with Internal and External Damping in Consideration of the Gyroscopic Effect of the Rotor Mass

H. Pfützner

Technische Univ. Berlin, Inst. f. Mechanik, Berlin, Germany, Forsch. Ingenieurw., 42 (4), pp 130-135 (1976) 7 figs, 6 refs

Key Words: Shafts, Dynamic stability, Internal damping, External damping, Gyroscopic effects, Rotors

In the case of rotating shafts internal damping can provoke self-excited bending vibrations. With regard to a Laval shaft without gyroscopic effect we know that when reaching a certain speed, instability will arise. Considering the gyroscopic effect of the rotor mass, this limit speed shifts upwards or downwards. In this study it is demonstrated that this shift of the limit speed for a Laval shaft can be shown generally taking all system parameters into account.

77-73

Influence of Shaft Runout on Vibration Analysis

J.L. Frarey

Shaker Research Corp., Ballston Lake, NY, ASME Paper No. 76-DE-38

Key Words: Shafts, Dynamic balancing, Diagnostic techniques

The use of noncontacting sensors to measure shaft motions is becoming standard practice. These measurements have been extremely useful in diagnosing a machinery condition and in dynamically balancing the shaft. Since the sensors measure the gap between the probe and the shaft, the output is a combination of both vibration and shaft physical properties such as ellipticity and surface imperfection commonly called runout. This paper discusses the effect that this runout error can have on interpreting the data and describes a method for correcting this error. Both corrected and uncorrected data are shown to illustrate the effect of the error. Balancing errors will be estimates that result from not correcting for runout.

77-74

Analytical Prediction of the Non-Linear Response of a Self-Excited Structure

A.O. St. Hilaire

United Technologies Research Center, East Hartford, CT 06118, J. Sound Vib., 47 (2), pp 185-205 (July 22, 1976) 6 figs, 7 refs

Key Words: Self-excited vibrations, Rods, Aircraft wings, Flutter

The time-dependent amplitude response of the self-excited harmonium reed vibrating at finite amplitudes in investigated both analytically and experimentally. The analysis contained herein is based on the assumption that all of the significant non-linear forces that act on the reed are of aerodynamic origin and that these forces influence the reed behavior through the system damping. The analysis is carried out, without the aid of empirical techniques, by deriving the induced aerodynamic pressure force as a non-linear function of the amplitude of the reed motion, via an unsteady potential flow field analysis, and then applying the resulting forcing function to the equation of motion of the reed. An approximate solution of the equivalent lumped parameter equation of motion yields functional relationships that predict various observable phenomena, including the limit cycle amplitude. A comparison of the results with experimental data serves to substantiate the analysis. Also presented is a brief discussion of some of the phenomenological similarities that exist between the results of the harmonium reed analysis and the observed behavior of a flat-plate wing undergoing torsional stall flutter.

77-75

Vibration Analysis of Grid-Works

H.V.S.G. Rao

Dept. of Civil Engrg., West Virginia Univ., Morgantown, WV 26505, Shock and Vibration Digest, 8 (9), pp 25-30 (Sept 1976) 2 figs, 25 refs

Key Words: Grids (beam grids), Shells, Numerical analysis, Vibration response

This article reviews several mathematical techniques that have been used to analyze planar grid-works and grid-work shells under dynamic loads. Numerical methods are used to determine differences between distributed versus lumped mass idealizations, torsional effects, boundary variations, spacing, and stiffness of beams.

77-76

Stability and Mass Optimization of Non-Conservative Euler Beams with Damping

C.R. Thomas

Benet Weapons Lab., Watervliet Arsenal, Watervliet, NY 12189, J. Sound Vib., 47 (3), pp 395-401 (Aug 8, 1976) 4 figs, 6 refs

Key Words: Beams, Euler-Lagrange equation, Stability, Optimization, Internal damping, External damping

A dimensionless stability problem together with its adjoint problem has been formulated for non-conservative, cantilevered Euler beams with linear external damping and internal damping according to the standard linear model. Stability and mass optimization are considered for a beam with a linear distributed tangential load acting along the centerline. Graphical optimization plots are shown and utilized as initial guesses in a Rosenbrock optimization routine which indicates mass reductions in the range of 20% to in excess of 30% are possible.

77-77

Non-Planar, Non-Linear Oscillations of a Beam. II. Free Motions

C.H. Ho, R.A. Scott and J.G. Eisley

General Electric Materials and Processes Lab., Schenectady, NY, J. Sound Vib., 47 (3), pp 333-339 (Aug 8, 1976) 1 fig, 6 refs

Sponsored by the National Science Foundation

Key Words: Beams, Free vibration, Whirling

Steady and unsteady free motions of compact beams with fixed ends are examined. It is found that in certain situations planar motions are unstable to out-of-plane perturbations and whirling motions occur. In resonant cases these whirling motions are of the beating type, whereas in non-resonant situations they have a steady-state behavior.

77-78
Vibration Damping Characteristics of Multilayered Beams with Constrained Viscoelastic Layers

N.T. Asnani and B.C. Nakra
Dept. of Mechanical Engrg., Indian Inst. of Tech., Delhi Hauz Khas, New Delhi, India, J. Engr. Indus., Trans. ASME, 98 (3), pp 895-901 (Aug 1976 10 figs, 9 refs

Key Words: Beams, Laminates, Viscoelastic core-containing media, Vibration damping, Viscoelastic damping

Results are reported on damping effectiveness during flexural vibrations of multilayered beams, with constrained visco-elastic layers. These are given for simply supported beams with number of layers up to 15, all viscoelastic layers being identical. The elastic layers are also taken to be similar to one another. The influence of number of layers and thickness ratio of viscoelastic to elastic layers, for constant size, constant weight and constant static stiffness criteria, has been studied. In order to obtain maximum value of loss factor or of displacement response effectiveness for multilayered beams, under specific requirements of static stiffness, weight and size, a suitable choice of number of layers and thickness ratio of viscoelastic to elastic layers, is found to be important.

•77-79
Natural Frequencies of Vibration of Cantilever Sandwich Beams

N.A. Rubayi and S. Charoenree
Dept. of Engrg. Mechanics and Materials, Southern Illinois Univ., Carbondale, IL 62901, Computers and Struc., 6 (4/5), pp 345-353 (Aug/Oct 1976) 7 figs, 17 refs

Key Words: Cantilever beams, Beams, Sandwich structures, Natural frequencies

Theoretical and experimental studies were made in obtaining the natural frequencies of cantilever sandwich beams subjected to only gravity forces. The method of minimizing the total energy of the system was used for determining the frequencies. A vibration system made by Unholtz-Dickie was utilized to set the beam in vibration. Resonance occurred when the frequency of the shaker coincided with the natural frequency of the beam. The resonance frequencies were measured by transducers mounted at various locations on the beam. A total of sixteen beams of various lengths, thickness and core density were tested.

77-80
Approximate Analysis of a Pile Under Dynamic, Lateral Loading

O.I. Ghazzaly, S.T. Hwong and M.W. O'Neill
Dept. of Civil Engrg., Univ. of Houston, Houston, TX 77004, Computers and Struc., 6 (4/5), pp 363-368 (Aug/Oct 1976) 3 figs, 27 refs

Key Words: Pile structures, Beams, Elastic foundations, Vibration response

An analytical study of the behavior of a vertical pile subjected to low-amplitude, periodic, surface, lateral loading was performed. A rational approach is proposed in which the pile response is represented by the vibrations of a beam on elastic foundation. The foundation medium is considered as a linearly elastic half-space whose properties are expressed by the shear modulus and Poisson's ratio. The appropriate dynamic properties of soils are introduced to describe the behavior of the foundation medium. The reliability of the proposed method of analysis is illustrated by comparing bending moments and deflections measured in tests on instrumented, small-scale piles embedded in cohesive and cohesionless soils and subjected to low-amplitude lateral vibrations, with computed values. The agreement between the computed and measured results was generally acceptable.

77-81
Dynamical Behaviours of Elastically Connected Double-Beam Systems Subjected to an Impulsive Load

S. Chonan
Dept. of Engrg., Tohoku Univ., Sendai, Japan, Bull. JSME, 19 (132), pp 595-603 (June 1976) 9 figs, 16 refs

Key Words: Beams, Plates, Elastic foundations, Impact response, Mass-spring systems

The dynamic behavior of two beams connected with a set of independent springs and subjected to an impulsive load are reported. The effect of the spring mass is taken into account. The solution is formulated by the method of the Laplace transformations with respect to both time and space variables, which allows analysis of all the major performance characteristics in the system subjected to an arbitrarily distributed impulsive load. As a numerical example, the case of a concentrated half-sine impulsive force applied to the mid point of the upper beam is treated.

77-82

An Approximate Method of Predicting the Response of Periodically Supported Beams Subjected to Random Convected Loading

D.J. Mead and A.K. Mallik

Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton SO9 5NH, England, J. Sound Vib., 47 (4), pp 457-471 (1976) 8 figs, 7 refs

Key Words: Beams, Elastic foundations, Random response, Approximation methods

The space-averaged response of an infinite, elastically supported, periodic beam subjected to convected random loading has been studied by using an approximate "assumed mode" method. The complex wave motion in the beam is represented by any number of suitably chosen complex modes. With a good, yet simple, choice of mode which satisfies certain boundary conditions on one periodic beam element, a "single mode approximation" can yield very accurate values of the average response. This has been verified for a wide range of the support stiffnesses and loading convection velocities. Consideration has also been given to the ratio of the maximum response in the beam to the space-averaged response. The method has been applied only to uniform beams in this paper, but it should be readily applicable to periodic systems consisting of non-uniform beam elements.

77-83

Critical Velocity of a Load Moving on a Beam Supported by an Elastic Stratum

S. Chonan

Dept. of Engrg., Tohoku Univ., Sendai, Japan, Bull. JSME, 19 (132), pp 604-609 (June 1976) 7 figs, 21 refs

Key Words: Beams, Elastic foundations, Winkler foundations, Moving loads

The present paper investigates the characteristics of the critical velocity of a load moving on a beam supported by an elastic stratum. In the analysis it is assumed that the stratum is a continuum which is homogeneous, isotropic, and linearly elastic. Both welded and smooth contacts between beam and foundation are considered. The influence of the density and the thickness of a foundation on the critical velocities is studied. The results are compared with those obtained from the Winkler assumption. It is found that the critical velocities for smooth contact are not so different from those for welded contact.

77-84

Forced Vibrations of Viscoelastic Timoshenko Beams

C.C. Huang and T.C. Huang

Dept. of Mech. Engrg., Univ. of Western Australia, Nedlands, Western Australia, J. Engr. Indus., Trans. ASME, 98 (3), pp 820-826 (Aug 1976) 8 figs, 4 refs

Sponsored by the National Science Foundation

Key Words: Beams, Viscoelastic properties, Timoshenko theory, Forced vibrations

In a previous paper, the correspondence principle has been applied to derive the differential equations of motion of viscoelastic Timoshenko beams with or without external viscous damping. To study free vibrations these equations are solved by Laplace transform and boundary conditions are applied to obtain the attenuation factor and the frequency of the damped free vibrations and mode shapes. The present paper continues to analyze this subject and deals with the responses in deflection, bending slope, bending moment and shear for forced vibrations. Laplace transform and appropriate boundary conditions have been applied. Examples are given and results are plotted. The solution of forced vibrations of elastic Timoshenko beams obtained as a result of reduction from viscoelastic case and by eigenfunction expansion method concludes the paper.

77-85

Optimal Estimation of the Response of Internally Damped Beams to Random Loads in the Presence of Measurement Noise

C.W. De Silva

Dept. of Aerospace Engrg., Univ. of Cincinnati, Cincinnati, OH 45221, J. Sound Vib., 47 (4), pp 485-493 (1976) 1 fig, 8 refs

Key Words: Beams, Internal damping, Viscoelastic damping, Hysteretic behavior, Random response

A technique is suggested to determine an optimal estimate of beam response to random loads when a set of response measurement noise is available. A beam with internal damping represented by a frequency dependent Kelvin-Voigt model is considered. This model introduces both viscoelastic and hysteretic internal damping. Kalman filter theory is used in solving the stochastic estimation problem. A numerical example is given at the end to illustrate the effectiveness of the proposed method.

77-86

Dynamic Properties of a Moving Thread Line

M.A. Moustafa and F.K. Salman
Mechanical Engrg. Dept., Univ. of Alexandria, Alexandria, Egypt, J. Engr. Indus., Trans. ASME, 98 (3), pp 868-875 (Aug 1976) 19 figs, 8 refs

Key Words: Strings, Mathematical models, Flexural vibrations

A mathematical model representing the transverse vibration of axially moving elastic strings is presented considering tension and mass variation. A suggested numerical scheme was successfully used to solve the nonlinear partial differential equations of motion. For axially nonmoving strings, the effect of initial amplitudes, and consequently the tension variation on the fundamental frequency is obtained. The effect of the initial tension and the mass of the string per unit length on the fundamental frequency and their corresponding mathematical relations are presented. For axially moving strings, the effect of the axial velocity on the fundamental frequency as well as the tension distribution along the thread is given. The behavior of the string at velocities equal and greater than the wave speed is shown.

77-87

Dynamics of a Drifting Buoy-Cable-Array Assembly Used in Submarine Detection

V.J. Modi and A.K. Misra
Dept. of Mech. Engrg., The Univ. of British Columbia, Vancouver, B.C., J. Engr. Indus., Trans. ASME, 98 (3), pp 935-940 (Aug 1976) 5 figs, 3 refs

Key Words: Buoys, Cables (ropes), Sono buoys

The paper investigates the dynamics of a drifting buoy-cable-array assembly used in submarine detection. The steady-state configurations of the three-dimensional cable and flexible legs are determined. A perturbation analysis around the steady state is carried out, and the frequencies for both lateral and longitudinal motions of the system obtained by analyzing the resulting eigenvalue problem. A study of the decay of the disturbances applied to the system suggests the use of an optimum arm diameter for given cable and arm lengths.

77-88

Equilibrium and Natural Frequencies of Cable Structures (A Nonlinear Finite Element Approach)

W.M. Henghold and J.J. Russell
Dept. of Civil Engrg., Engrg. Mechanics and Materials, U.S. Air Force Academy, CO 80840, Computers and Struc., 6 (4/5), pp 267-271 (Aug/Oct 1976) 1 fig, 9 refs

Key Words: Cables (ropes), Natural frequencies, Finite element technique

This paper concerns the finite element method as applied to cable structures. A family of nonlinear elements is developed. The class of elements developed retains all geometric nonlinearities and allows for any elastic deformation. The problems of static deflection and natural frequency determination for small oscillations about the nonlinear equilibrium position are investigated for single-span cables.

77-89

An Application of the Finite Element Method to the Determination of Nonlinear Static and Dynamic Responses of Underwater Cable Structures

R.L. Webster
Ph.D. Thesis, Cornell Univ., 334 pp (1976)
UM 76-21, 140

Key Words: Cables (ropes), Underwater structures, Dynamic response, Finite element technique

The common approaches to the analysis of underwater cable structures are reviewed to identify their essential features. Nonlinear effects which are shown to be important in dealing with underwater cables are geometric nonlinearities, nonlinear material response (including zero compression stiffness), velocity-squared drag resistance, and position-dependent loading, mass and boundary conditions. The general form of the governing equations for the structural response of a continuum having these nonlinearities in combination is developed. A finite element discretization is introduced using displacement shape functions, and these general developments are then specialized to the case of a one-dimensional element in three-dimensional space which is applied to the cable problem.

BEARINGS

77-90

Experimental Dynamic Stiffness and Damping of Externally Pressurized Gas-Lubricated Journal Bearings

D.P. Fleming, W.J. Thayer and R.E. Cunningham
Lewis Research Ctr., NASA, Cleveland, OH., Rept. No. NASA-TN-D-8270; E-8636, 28 pp (June 1976)
N76-26515

Key Words: Journal bearings, Shafts, Dynamic stiffness, Damping

A rigid vertical shaft was operated with known amounts of unbalance at speeds to 30,000 rpm and gas supply pressure ratios to 4.8. From measured amplitude and phase angle data, dynamic stiffness and damping coefficients of the bearings were determined. The measured stiffness was proportional to the supply pressure, while damping was little affected by supply pressure. Damping dropped rapidly as the fractional frequency whirl threshold was approached. A small-eccentricity analysis overpredicted the stiffness by 20 to 70 percent. Predicted damping was lower than measured at low speeds but higher at high speeds.

77-91

Predicting Natural Frequencies of a Hydrodynamically Lubricated Journal Bearing with Constant Oil Supply Pressure

D.C. Edwards, N. Khorzad and C.L. Edwards

Fiber Industries, Inc., Charlotte, NC, J. Engr. Indus., Trans. ASME, 98 (3), pp 980-987 (Aug 1976) 14 figs, 7 refs

Key Words: Journal bearings, Natural frequencies

The analytical and experimental investigations reported here deal with the natural frequencies and system behavior of a full journal bearing subjected to a small sinusoidal load superimposed on a large unidirectional static load. The analysis, verified by experimentation, shows that the bearing can be regarded as two independent second-order systems acting perpendicular to each other. The variable coefficients of the equations of motion cause the bearing to behave as an underdamped system for low values of static eccentricity ratio ϵ_0, and as an overdamped system for intermediate values of ϵ_0. The bearing tends to be unstable above a particular ϵ_0. Further analysis is needed to determine the effects resulting from changing the oil inlet pressure.

BLADES

77-92

Nonlinear Equations of Motion for Cantilever Rotor Blades in Hover with Pitch Link Flexibility, Twist, Precone, Droop, Sweep, Torque Offset and Blade Root Offset

D.H. Hodges

Ames Research Center, NASA, Moffett Field, CA, Rept. No. NASA-TM-X-73112; A-6486, 47 pp (May 1976)

N76-26152

Key Words: Rotary wings, Cantilever beams, Equations of motion

Nonlinear equations of motion for a cantilever rotor blade are derived for the hovering flight condition. The blade is assumed to have twist, precone, droop, sweep, torque offset and blade root offset, and the elastic axis and the axes of center of mass, tension, and aerodynamic center coincident at the quarter chord. The blade is cantilevered in bending, but has a torsional root spring to simulate pitch link flexibility. Aerodynamic forces acting on the blade are derived from strip theory based on quasi-steady two-dimensional airfoil theory. The equations are hybrid, consisting of one integro-differential equation for root torsion and three integro-partial differential equations for flatwise and chordwise bending and elastic torsion. The equations are specialized for a uniform blade and reduced to nonlinear ordinary differential equations by Galerkin's method. They are linearized for small perturbation motions about the equilibrium operating condition. Modal analysis leads to formulation of a standard eigenvalue problem where the elements of the stability matrix depend on the solution of the equilibrium equations. Two different forms of the root torsion equation are derived that yield virtually identical numerical results. This provides a reasonable check for the accuracy of the equations.

77-93

Guide Vane Vibrations Caused by Wakes and Blower Noise. Part I: The Vortex Degeneration in the Asymmetrical Wakes

Y.N. Chen, G. Baylac and R. Walther

Vibration and Acoustic Lab., Sulzer Brothers, Ltd., Winterthur, Switzerland, J. Engr. Indus., Trans. ASME, 98 (3), pp 948-955 (Aug 1976) 6 figs, 24 refs

Key Words: Blades, Plates, Vortex-induced vibration, Fluid-induced vibration, Model testing

The symmetrical wakes beyond a guide vane cascade consisting of curved and flat plates with blunt trailing edges were investigated as far as the excited dynamic stresses in the blades and the vortex Strouhal number are concerned.

77-94

Guide Vane Vibrations Caused by Wakes and Blower Noise. Part II: Transferability From the Model to the Prototype

Y.N. Chen, G. Baylac and R. Walther

Vibration and Acoustic Lab., Sulzer Brothers, Ltd., Winterthur, Switzerland, J. Engr. Indus., Trans. ASME, 98 (3), pp 956-967 (Aug 1976) 1 fig, 3 refs

Key Words: Blades, Vortex-induced vibration, Fluid-induced excitation, Acoustic excitation, Model testing

Model tests were carried out on vibrations of guide vanes induced by wakes and noise. The results will be compared with the measurements on the prototype. It will be shown that the modeling law applies well for the wake-induced vibration. But for the noise-excited vibration, the model test with the loudspeaker noise gave too high a level of the dynamic stress compared with that in the prototype excited by the blower noise. This deviation can be attributed to the unsteady phase relationship of the noise generated by the turbomachinery. The acoustic resonances in the channels will be investigated both theoretically and experimentally. A damping of these resonances can be achieved by inserting cross plates into a part of the channel. The mechanical vibration of a turning blade can only be severely excited by the noise, as long as an acoustic resonance prevails in a neighboring channel near the corresponding frequency.

77-95

Dynamic Behavior of Laminated Polymeric Matrix Composites

R.W. Mortimer and P.C. Chou

Dept. of Mechanical Engrg. and Mechanics, Drexel Univ., Philadelphia, PA, Rept. No. AFML-TR-74-136, 61 pp (Mar 1976)
AD-A025 622/2GA

Key Words: Blades, Fans, Plates, Laminates

The dynamic response of idealized laminated graphite-epoxy fan blades subjected to impact loads is quantified experimentally and numerically. Two impact cases will be studied: one is the short-time local response, idealized by wave propagation in laminated plates. The other is the structural response idealized by laminated beam.

77-96

Vibration Analysis of Axial Flow Turbine Disks Using Finite Elements

G.J. Wilson and J. Kirkhope

Dept. of Engrg., Carleton Univ., Ottawa, Ontario, Canada, J. Engr. Indus., Trans. ASME, 98 (3), pp 1008-1013 (Aug 1976) 2 figs, 17 refs

Key Words: Turbine components, Turbine blades, Resonant response, Finite element technique

The finite element method is applied to the vibration analysis of axial flow turbine disks. Using the axi-symmetric properties of the configuration of such disks, several finite elements are developed to describe the bending of thin or moderately thick circular plates, and which are characterized by only four- or eight-degrees-of-freedom. These elements incorporate the desired number of diametral nodes in their dynamic deflection functions, and allow for any specified thickness variation in the radial direction. In addition, the effects of in-plane stresses which might arise from rotation or radial temperature gradient, and the effects of transverse shear and rotary inertia in moderately thick plates are readily accounted for. The accuracy and convergence of these elements is demonstrated by numerical comparison with both exact and experimental data for disks.

CYLINDERS

(See Nos. 20, 47)

DUCTS

(Also see Nos. 30, 145)

77-97

The Evaluation of Circular Silencers

F.P. Mechel

Grünzweig Hartmann and Glasfaser AG., Ludwigshafen/Rhein Universität des Saarlandes, Labor Akustik, Saarbrücken, Germany, Acustica, 35 (3), pp 179-189 (June 1976) 13 figs, 6 refs
(In German)

Key Words: Sound attenuation, Acoustic absorption, Ducts, Acoustic linings

The paper describes an approximate formula of high accuracy for the calculation of the sound attenuation in circular silencers. The formula is derived for sound fields with axial symmetry as well as for higher circumferential modes. The approximation covers the two first radial modes. It yields the sound attenuation in a straightforward manner for locally reactive absorbers. For absorbers with sound propagation parallel to the duct axis in the interior of the absorber material, an iterative procedure is described. The numerical computation of complex Bessel functions is given in the appendix.

77-98

A Reciprocity Relationship for Transmission in Non-Uniform Hard Walled Ducts Without Flow

W. Eversman

Dept. of Mechanical Engrg., Univ. of Canterbury, Christchurch, New Zealand, J. Sound Vib., 47 (4), pp 515-521 (1976) 1 fig, 3 refs

Key Words: Ducts, Elastic waves, Sound transmission, Sound reflection, Reciprocity principle

A reciprocity relationship for the reflection and transmission coefficients for the propagation of sound in a non-uniform hard walled duct is derived. The relationship is based on a similar one previously known in the theory of electromagnetic waveguides. An example calculation is shown to support the relationship.

77-99

On the Reduction of Compressor Noise by Means of Helical Detuners

D. Lohmann

European Space Agnecy, Paris, France, In: Engine Noise (ESA-TT-244), pp 123-137 (Feb 1976) (Engl. transl. from "Triebwerkslaerm", DGLR, Cologne Rept. DLR-Mitt-74-21, 1974, pp 119-132 (N76-24243)

N76-24250

Key Words: Compressor noise, Ducts, Noise reduction

Tests were carried out on engine intake detuners whose configuration takes ᵒarticular account of the qualitative properties of the compressor noise field. The helical detuners generate a vortex flow in the intake duct which exerts a favorable effect on acoustic cutoff. The solution of the wave equation yields damping and displacement of the natural frequencies as a function of the geometry of the detuners, which it was possible to verify by means of noise field measurements in model ducts. Other acoustic measurements in ducts with a flow passing through them show that the level of the noise field also decreases as a result of the flow.

77-100

Field Versus Laboratory Ratings of Grilles, Registers and Diffusers

R.S. Jones

Bolt Beranek and Newman, Inc., Cambridge, MA, S/V, Sound Vib., 10 (6), pp 30-32 (June 1976) 7 figs

Key Words: Ducts, Air conditioning equipment, Noise generation

In normal field installation of grilles, registers and diffusers for air-handling systems, optimum entrance conditions to terminal units are seldom or never realized. This article discusses differences in generated noise level, as related to duct connections at terminal devices, between optimum laboratory test conditions and actually installed configurations, dictated by job conditions. Examples are used to describe the effect of properly designed and installed ducts leading to air terminals and, by contrast, what happens when optimum or recommended conditions are compromised and air volume control devices are misapplied. Examples of remedial treatment and the resulting noise reduction are described.

77-101

Optimization of Suppression for Two-Element Treatment Liners for Turbomachinery Exhaust Ducts

R.E. Motsinger, R.E. Kraft, J.W. Zwick, S.I. Vukelich, G.L. Minner and K.J. Baumeister

General Electric Co., Cincinnati, OH., Rept. No. NASA-CR-134997; R76AEG256, 132 pp (Apr 1976) N76-24995

Key Words: Ducts, Turbomachinery, Acoustic linings, Modal analysis

Sound wave propagation in a soft-walled rectangular duct with steady uniform flow was investigated at exhaust conditions, incorporating the solution equations for sound wave propagation in a rectangular duct with multiple longitudinal wall treatment segments. Modal analysis was employed to find the solution equations and to study the effectiveness of a uniform and of a two-sectional liner in attenuating sound power in a treated rectangular duct without flow and with uniform flow of Mach 0.3.

GEARS

77-102

Expected and Maximum Permissible Values for Sound Radiation in Industry Gear Transmission

M. Wiltzsch

WEB WTZ Getriebe und Kuplungen, Magdeburg, Germany, Maschinenbautechnik, 76 (7), pp 294-300 (July 1976) 5 figs, 6 refs

(In German)

Key Words: Gears, Noise generation

A procedure for deriving an approximate regression function for the expected sound radiation values of gear transmissions is described. It is tested and adjusted by means of over 2000 experimental data. The maximum permissible sound emission value is set at between 10 and 3000 kW. Diagrams for the determination of the expected values of noise levels of transmission gears are presented.

77-103
Dynamic Behavior of Planetary Gear (1st Report: Load Distribution in Planetary Gear)

T. Hidaka and Y. Terauchi

Dept. of Engrg., Hiroshima Univ., 3 Sendamachi Hiroshima, Japan, Bull. JSME, 19 (132), pp 690-698 (June 1976) 16 figs, 5 refs

Key Words: Gears, Dynamic response

A systematic experimental study was carried out to determine inequality of load distribution using a Stoekicht planetary gear with spur gears. The mean values of load distribution among the planetary gears are nearly equal, but variations of dynamic tooth loads grow large in the high-speed range.

77-104
Epicyclic Gear Vibrations

M. Botman

Pratt and Whitney Aircraft of Canada, Ltd., Longueuil, Quebec, Canada, J. Engr. Indus., Trans. ASME, 98 (3), pp 811-815 (Aug 1976) 10 figs, 9 refs

Key Words: Gears, Natural frequencies, Springs

The natural frequencies of in-plane vibration of a single planetary gear stage are analyzed. The gear tooth stiffnesses are approximated as linear springs. The effect of planet pin stiffness on the natural frequencies is evaluated. Rotation of the carrier gives rise to a system with periodic coefficients which is solved by means of Floquet's theory. The rotation of the carrier appears to suppress the nonaxisymmetric modes which are present in the system with nonrotating carrier.

LINKAGES

77-105
Determination of Joint Stiffness in Bolted Connections

N. Motosh

Dept. of Engrg., Assiut Univ., Assiut, Egypt, J. Engr. Indus., Trans. ASME, 98 (3), pp 858-861 (Aug 1976) 8 figs, 6 refs

Key Words: Joint stiffness

The correct determination of the joint stiffness is of extreme importance in the design of bolted connections. In a preloaded joint the increase in bolt tension due to external load application, whether static, or dynamic, depending on both bolt stiffness and joint stiffness is reported.

MEMBRANES, FILMS, AND WEBS

77-106
Measurement of the Elastic Moduli of Structural Adhesives by a Resonant Bar Technique

R.D. Adams and J. Coppendale

Dept. of Mechanical Engrg., Univ. of Bristol, England, J. Mech. Engr. Sci., 18 (3), pp 149-158 (June 1976) 10 figs, 10 refs

Key Words: Modulus of elasticity, Torsional response, Adhesives, Resonant bar technique

A method of measuring the dynamic torsion and Young's moduli of a thin film of adhesive is described. The accuracy of the technique and its suitability for structural adhesives is discussed. Values of modulus obtained using this method are compared with values obtained from static and dynamic tests on bulk specimens of three epoxy adhesives.

PANELS
(Also see No. 39)

77-107
On the Aeroelastic Instability of Two-Dimensional Panels in Uniform Incompressible Flow

A. Kornecki, E. H. Dowell and J. O'Brien

Dept. of Agricultural Engrg., Technion - Israel Inst. of Technology, Haifa, Israel, J. Sound Vib., 47 (2), pp 163-178 (July 22, 1976) 7 figs, 20 refs

Sponsored by the Science Res. Council of UK and Royal Aircraft Establishment

Key Words: Panels, Aeroelasticity, Flutter

A theoretical and experimental study is presented of the aeroelastic instability of a panel with various boundary conditions on its leading and trailing edges, exposed to air flow over its upper surface or on both sides. The flow is incompressible and two-dimensional (no span-wise deformation of the panel). The case of a panel clamped at its leading edge and free at its trailing edge is investigated both theoretically and experimentally. Agreement between theory and experiment is fair. The aerodynamic theory of steady non-circulatory flow is applied for panels fixed at both ends, and the quasi-steady and full unsteady aerodynamic lifting theories to a cantilevered panel (free at the trailing edge). The analogy with incompressible flow through a long slender tube is pointed out.

77-108

Acoustical Effects in Panel Response to Supersonic Turbulence

L.D. Pope

Bolt Beranek and Newman, Inc., Canoga Park, CA 91303, J. Acoust. Soc. Amer., 60 (2), pp 384-394 (Aug 1976) 8 figs, 9 refs

Key Words: Panels, Turbulence, Fluid-induced excitation, Acoustic response

Acoustical coupling of a turbulence-excited panel and a supersonically moving fluid is investigated. Response of a panel with a single rib discontinuity is considered. Radiation from the panel into the fluid induced by a uniform line force is investigated and the line admittance of the panel in the presence of supersonic flow is obtained. Numerical results are presented for the line admittance and for the ribbed and unribbed infinite panel response. A relation is given which upon integration will yield the radiation damping of a finite panel (radiation into the supersonic flow).

PIPES AND TUBES

(Also see No. 142)

77-109

Transmission of Low-Frequency Internal Sound Through Pipe Walls

G.F. Kuhn and C.L. Morfey

Institute of Sound and Vibration Research, Univ. of Southampton, Southampton SO9 5NH, England, J. Sound Vib., 47 (2), pp 147-161 (July 22, 1976) 16 figs, 9 refs

Key Words: Pipes (tubes), Curved pipes, Sound transmission loss

Transmission loss measurements are reported for long steel pipes of circular cross-section, with air inside and out, exicted by internal sound. At low frequencies (wavelength greater than the pipe diameter), most of the radiated sound is accounted for by pipe bending waves. In order to approach the much higher transmission loss predicted for pure breathing motion of the pipe, bending waves must be suppressed; this has been achieved for a straight pipe by careful isolation.

77-110

Transient Analysis of Air Vessels and Air Inlet Valves

C.N. Papadakis and S.T. Hsu

Bechtel, Inc., Gaithersburg, MD, ASME Paper 76-FE-28

Key Words: Valves, Transient response

Air vessels and air inlet valves are installations often recommended for controlling waterhammer in piping systems. Equations modeling the transient behavior of these devices are presented in suitable form and are solved in conjunction with the unsteady-pipe-flow characteristics equations. Two examples of the transient performance of air vessels and air inlet valves are presented to illustrate the applicability of the method. Published results from other techniques are used for comparison.

PLATES AND SHELLS

(Also see Nos. 12, 18, 38, 66, 81, 93, 130, 141)

77-111

Harmonic Vibrations of Isotropic, Elastic, and Elastic/Viscoelastic Three-Layered Plates

L.L Durocher and R. Solecki

Dept. of Mechanical Engrg., Univ. of Bridgeport, Bridgeport, CT., J. Acoust. Soc. Amer., 60 (1), pp 105-112 (July 1976) 9 figs, 20 refs

Key Words: Plates, Laminates, Harmonic response, Transverse shear deformation effects, Rotatory inertia effects

A fourth-order equation has been derived that is suitable for analyzing symmetrically constructed, isotropic three-layer plates. The formulation includes the effects of shear deformation in each layer, as well as the rotatory inertia of the composite while enforcing continuity of displacements and shear stresses at layer interfaces. Natural frequency comparisons have shown that the current theory is in excellent agreement with an exact elasticity solution, at least in the range where such data exists. By using the complex modulus concept or the correspondence principle, the governing equation can be used in analyzing composite plates that consist of (a) a viscoelastic core sandwiched between similar elastic faces and (b) an elastic plate with two symmetric viscoelastic coatings. Several examples have been analyzed to illustrate the damping that can be obtained by the use of a viscoelastic inner layer.

77-112

Large Deflection Vibration of Cross-Ply Laminated Plates with Certain Edge Conditions

R. Chandra

Structural Sciences Div., National Aeronautical Lab., Bangalore 560017, India, J. Sound Vib., 47 (4), pp 509-514 (1976) 2 figs, 6 refs

Key Words: Plates, Laminates, Flexural vibration

This paper deals with the large deflection flexural vibration of unsymmetric cross-ply laminated plates which are simply supported at two opposite edges and clamped at the other two edges. Stress-free and movable in-plane boundary conditions are considered. Non-linear frequency is obtained as a function of lamination parameters, material constants, aspect ratio, linear frequency and amplitude of vibration. Non-linear frequency to linear frequency ratio versus amplitude curves are presented for isotropic, glass-epoxy, graphite-epoxy and boron-epoxy plates.

77-113

Dynamic Response of Anisotropic Laminated Plates Under Initial Stress to Impact of a Mass

C.T. Sun and S. Chatopadhyay
School of Aeronautics, Astronautics and Engrg. Sciences, Purdue Univ., Lafayette, IN, Rept. No. AFML-TR-74-258, 44 pp (Mar 1976)
AD-A025 906/9GA

Key Words: Plates, Laminates, Composites, Dynamic response

The impact of a central mass on a simply-supported laminated composite plate under initial stress is investigated. The energy transferred from the mass to the plate during impact is obtained by use of a normalized contact force.

77-114

On the Dynamic Response of a Rectangular Sandwich Plate with Viscoelastic Core and Generally Orthotropic Facings

A.K. Mukhopadhyay and H.B. Kingsbury
Dept. of Mech. and Aerospace Engrg., Univ of Delaware, Newark, DE 19711, J. Sound Vib., 47 (3), pp 347-358 (Aug 8, 1976) 9 figs, 18 refs

Key Words: Plates, Sandwich laminates, Viscoelastic core-containing media, Fourier series, Dynamic response

This paper explores the effect of facing anisotropy on the damped response to harmonic transverse dynamic loads of a rectangular sandwich plate with a viscoelastic core. The membrane facings are generally orthotropic and the measure of anisotropy is the angle between the geometric plate axes and the elastic axes of the facing material. A Fourier series solution is obtained to the governing plate equations for the case of simply supported edges. The response of the plate at fundamental resonance for several loss factors between 0 and 1 is computed for varying facing anisotropy.

77-115

Eigenvalues of Orthotropic Continuous Plates with Two Opposite Sides Simply Supported

T. Sakata
Dept. of Mechanical Engrg., Chubu Inst. of Tech., Kasugai, Nagoya-sub., Japan 487, J. Sound Vib., 47 (4), pp 577-583 (1976) 4 refs

Key Words: Rectangular plates, Eigenvalue problems, Orthotropism

It is shown that the eigenvalue of an othrotropic continuous plate with sides a and b can be obtained from the eigenvalue of a corresponding isotropic continuous plate by the use of a reduction formula.

77-116

Dynamics of Initially Stressed Plates

H. Reismann and Z.A. Tendorf
State Univ. of New York, Buffalo, NY, J. Appl. Mech., Trans. ASME, 43 (2), pp 304-308 (June 1976) 6 figs, 3 refs

Key Words: Rectangular plates, Initial deformation effects

A formalism is presented for the solution of supported plates of bounded extent, subjected to time-dependent transverse forces and boundary conditions. Initially, and during the course of the motion, the plate is assumed to be in an arbitrary (stable) state of membrane stress. An example of a suddenly loaded, simply supported rectangular plate is presented. The membrane prestress, in the example problem, is assumed to be constant and parallel to two opposite edges of the plate.

77-117

Vibrations of a Circular Plate Having Partly Clamped or Partly Simply Supported Boundary

Y. Hirano and K. Okazaki
Dept. of Engrg., Yamagata Univ., Yonezawa, Japan, Bull. JSME, 19 (132), pp 610-618 (June 1976) 7 figs, 10 refs

Key Words: Circular plates, Flexural vibrations

This paper deals with the flexural vibrations of a circular plate under various mixed boundary conditons. The mixed constraint conditions for the displacements of the plate on its circumference are formulated by means of the weighted residual method, and the corresponding dynamical boundary conditions are derived. Numerical calculations are carried out for three examples; one is of a circular plate clamped on part of its boundary and simply supported on the remainder, another, partly simply supported and partly free, and a third, partly clamped and partly free. An experiment is made on the last example.

77-118

Axisymmetric Vibrations of Circular Plates Including the Effects of Geometric Non-Linearity, Shear Deformation and Rotary Inertia

K.K. Raju and G.V. Rao

Vikram Sarabhai Space Centre, Trivandrum-695022, India, J. Sound Vib., 47 (2), pp 179-184 (July 22, 1976) 9 refs

Key Words: Axisymmetric vibrations, Circular plates, Geometric imperfection effects, Transverse shear deformation effects, Rotatory inertia effects

In this paper, axisymmetric vibrations of circular plates are studied, with inclusion of the effects of geometric nonlinearity, shear deformation and rotatory inertia. The finite element method is employed to formulate the problem. Both simply supported and clamped plates are considered.

77-119

Vibrations of an Infinite Plate with a Frequency Independent Q

M. Caputo

Istituto Nazionale de Geofisica, Roma, Italy, J. Acoust. Soc Amer., 60 (3), pp 634-639 (Sept 1976) 7 figs, 11 refs

Key Words: Plates, Vibration response

The dissipation in an elastic medium is represented by a dissipation mechanism which is similar to one used in an earlier paper by the author, but is simpler and has a frequency-independent Q^{-1}. The vibrations of a plate are studied by obtaining the eigenfrequencies, the amplitude of the displacement, the dispersion relation, the Q^{-1}, the hysteresis cycle, and the yield stress.

77-120

Large Amplitude Free Vibrations of Irregular Plates Placed on an Elastic Foundation

S. Datta

Dept. of Mech. Engrg. and Appl. Mech., Jalpaiguri Gov. Engrg. College, Jalpaiguri, W. Bengal, India, Intl. J. Nonlinear Mech., 11 (5), pp 337-345 (1976) 5 figs, 7 refs

Key Words: Plates, Elastic foundations, Natural frequencies, Conformal mapping, Galerkin method

A unified method for determining the lowest natural frequency of large amplitude free vibrations of thin elastic plates of any shape and placed on elastic foundation is given. The conformal mapping technique is introduced and Galerkin's method is used to calculate approximate values of the lowest natural frequency. Time periods for circular, square and cornered plates placed on elastic foundation have been determined for simply supported and clamped edge boundary conditions. Practical values have also been determined experimentally. The results are presented in the form of graphs and they are compared with other known results.

77-121

Transient Response of a Continuous Plate on Elastic Supports

K. Nagaya

Dept. of Engrg., Yamagata Univ., Jyonan, Yonezawa, Japan, J. Sound Vib., 47 (3), pp 359-370 (Aug 8, 1976) 7 figs, 12 refs

Key Words: Plates, Elastic foundations, Natural frequencies, Dynamic response, Laplace transformation

This paper discusses the vibration and the transient response problem of a non-periodically elastically supported continuous plate. In the analysis, the restoring forces of the elastic supports are formally represented, initially, as unknown external forces applied to the plate. Expressions for displacements and bending moments of the plate when it is subjected to impact loads are obtained from the equation of motion in terms of the "unknown" forces by using Laplace transform methods. The natural frequencies and dynamic responses of two-and three-span plates are shown in a numerical example, and the dynamic behavior of the plate is discussed in detail.

77-122

Dynamic Finite Element and Dynamic Photoelastic Analyses of Crack Arrest in Homalite-100 Plates

A.S. Kobayashi, A.F. Emery and S. Mall

Dept. of Mech. Engrg., Washington Univ., Seattle, WA, Rept. No. TR-25, 28 pp (May 1976)
AD-A025 626/3GA

Key Words: Plates, Fracture properties, Finite element technique, Photoelastic analysis, Computerized simulation, Computer programs

A dynamic finite element code, HONDO, was used to analyze four dynamic photoelastic experiments in which the propagating crack arrested.

77-123
Transient Dynamic and Inelastic Analysis of Shells of Revolution–A Survey of Programs
V. Svalbonas
Engrg. Dept., The Franklin Institute Research Laboratories, Philadelphia, PA 19103, Nucl. Engr. Des., 37 (1), pp 73-93 (Apr 1976) 22 figs, 59 refs

Key Words: Shells of revolution, Computer programs, Finite element technique, Finite difference theory, Numerical analysis

This survey of computer programs concentrates upon the analytical tools which have been developed predominantly for shells of revolution. The survey is subdivided into three parts: (a) consideration of programs for transient dynamic analysis; (b) consideration of programs for inelastic analysis and finally; (c) consideration of programs capable of dynamic plasticity analysis. In each part, programs based upon finite difference, finite element, and numerical integration methods are considered. The programs are compared on the basis of analytical capabilities, and ease of idealization and use. In each part of the survey sample problems will be utilized to exemplify the state-of-the-art.

77-124
Dynamic Rupture Analysis of Reinforced Concrete Shells
B. Rebora, T. Zimmermann and J.P. Wolf
IPEN, Institut de Production d'Energie, Ecole Polytechnique Federale de Lausanne, CH-1006 Lausanne, Switzerland, Nucl. Engr. Des., 37 (2), pp 269-297 (May 1976) 32 figs, 20 refs

Key Words: Shells, Reinforced concrete, Nuclear power plants, Finite element technique, Dynamic response, Fracture properties

Extreme dynamic loading conditions often require the rupture analysis of reinforced and prestressed-concrete structures. The study presented in this paper extends a method of analysis of dynamic loading conditions which has proven efficient for short- and long-time loads. Another aim is to adapt the method to thin-walled structures.

77-125
Axisymmetrical Vibrations of Underwater Hemispherical Shells
F.C. Chen and T.C. Huang
Univ. of Arkansas, Pine Bluff, AR, J. Engr. Indus., Trans. ASME, 98 (3), pp 941-947 (Aug 1976) 6 figs 6 refs

Key Words: Shells, Underwater structures, Free vibration, Interaction: structure-fluid

Free vibrations of an underwater elastic hemispherical thin shell with fixed edge have been investigated based on the bending theory. The solution of this fluid-solid interaction problem involves the differential equations of motion of underwater spherical shells, the velocity potential of the water field, the hydrodynamic pressure, and the continuity and boundary conditions. A transcedental frequency equation in terms of Legendre functions is derived and the normal and tangential mode shapes are found. Examples are given and results are plotted for natural frequencies and modes shapes.

77-126
Non-Linear Vibrations of a Shallow Cylindrical Panel on an Elastic Foundation
J. Ramachandran and P.A.K. Murthy
Dept. of Appl. Mech., Indian Inst. of Technology, Madras 600036, India, J. Sound Vib., 47 (4), pp 495-500 (1976) 3 figs, 9 refs

Key Words: Cylindrical shells, Orthotropism, Winkler foundations, Nonlinear theories, Snap-through problems

The dynamic von Karman field equations are used to analyse the influence of large amplitude on the free vibrations of shallow cylindrical shells made of orthotropic material and resting on an elastic Winkler foundation. The "snap-through" phenomenon for such shells subjected to a dynamically applied uniform pressure that increases linearly with time is also investigated.

77-127
Vibratory Response of Laminated Cylindrical Shells Embedded in an Acoustic Fluid
A. Harari and B.E. Sandman
Naval Underwater Systems Center, Newport, RI, J. Acoust. Soc. Amer., 60 (1), pp 117-128 (July 1976) 8 figs, 11 refs

Key Words: Cylindrical shells, Laminates, Fluid-induced excitation

The equations of motion for a three-layered cylindrical shell are derived. The thickness and material properties may be different for each layer. Dissipative materials may also be considered. The solution for a simply supported cylindrical shell excited by a time-harmonic load is obtained in vacuum and in a fluid-acoustic medium. The response of the shell and the corresponding acoustic pressure field is found and illustrated for a specific configuration.

77-128

Stress Wave Propagation in Maxwell Fluid Contained in Rigid Spherical Shells

K.B. Chandran, Y.K. Liu and D.U. Von Rosenberg
Biomechanics Lab., Tulane Univ. School of Medicine, New Orleans, LA 70112, J. Sound Vib., 47 (1), pp 107-114 (July 8, 1976) 4 figs, 13 refs

Key Words: Spherical shells, Maxwell fluid, Mathematical models, Head (anatomy)

For stress wave propagation in a rigid spherical shell containing Maxwell fluid subjected to translational and rotational acceleration, the solutions to the governing equations are obtained by employing a finite difference technique, when the input acceleration is a unit step function. The solutions can be extended to accelerations which are general functions of time with the proper discretization of the input acceleration curve. The radial and temporal distribution of the stress waves in both cases are presented. The solutions are also specialized for the case of purely viscous fluids. The applicability of this model for brain injury simulation is briefly discussed.

RINGS

77-129

In-Plane Vibrations of Annular Rings

G. Ambati, J.F.W. Bell and J.C.K. Sharp
Dept. of Electrical Engrg., The Univ. of Aston in Birmingham, Birmingham B4 7PB, England, J. Sound Vib., 47 (3), pp 415-432 (Aug 8, 1976) 3 figs, 11 refs

Key Words: Rings, Vibration response

The in-plane vibrations of thin disks and narrow thin rings which already have been completely analyzed are the two extremes of the annulus configuration. The general case of the annulus has now been analyzed and the results confirmed by experiment.

77-130

Dynamic Plastic Buckling of Rings and Cylindrical Shells

N. Jones and D.M. Okawa
Dept. of Ocean Engrg., Mass. Inst. of Technology, Cambridge, MA 02139, Nucl. Engr. Des., 37 (1), pp 125-147 (Apr 1976) 27 refs
Sponsored by the Office of Naval Research

Key Words: Rings, Cylindrical shells, Shock excitation, Pulse excitation, Dynamic buckling, Experimental data

An experimental investigation on the dynamic plastic buckling of circular rings subjected to uniformly distributed external impulsive velocities is reported. The experimental values of the average final radial deflections, critical mode numbers and dimensions of the permanent wrinkles in the mild steel and aluminum specimens are compared with various theoretical predictions and other expermental results.

STRUCTURAL

(Also see Nos. 41, 64)

77-131

Reverberation and Effective Absorption in Rooms with Diffuse Wall Reflexions

H. Kuttruff
Institut für Technische Akustik der Rheinisch-Westfälischen Technischen Hochschule Aachen, Acustica, 35 (3), pp 141-153 (June 1976) 9 figs
(In German)

Key Words: Acoustic absorption, Rooms, Monte Carlo method

On the basis of a rather general description of the decay process it is shown in this paper that the Eyring reverberation formula is not generally valid if the wall absorption is non-uniform. A more exact, though not closed computation procedure, however, leads to good agreement with the decay times obtained by the application of a Monte-Carlo-method. The influence of non-constant free-path lengths can be accounted for by a simple correction. A correction term to the Eyring formula is derived, by which the decay time of polyhedral rooms with non-uniform absorption can be calculated for practical use.

77-132

Punching of Flat Plates Under Static and Dynamic Horizontal Forces

A. Ghali, M.Z. Elmasri and W. Dilger
Dept. of Civil Engrg., Univ. of Calgary, Alberta, Canada, J. Amer. Concrete Inst., 73 (10), pp 566-572 (Oct 1976) 5 figs, 9 refs
Sponsored by the National Res. Council of Canada and Defense Res. Board of Canada

Key Words: Plates, Floors, Dynamic tests

The results of a laboratory investigation on the strength and deformation of flat slab floors at their connection with columns when subjected to static or dynamic horizontal forces are presented. Six full scale specimens of a slab-column connection were subjected to a constant axial force representing gravity load, and a varying static and dynamic moment transferred between the column and the slab. The amount of the flexure reinforcement in the slab was variable. No shear reinforcement was provided.

77-133

Sound Transmission Loss of Entrance Doors

T.B. Heebink

Pacific Northwest Forest and Range Experiment Station, Forest Service U.S. Dept. of Agriculture, Seattle, WA, S/V, Sound Vib., 10 (6), pp 26-29 (June 1976) 5 figs, 11 refs

Key Words: Sound transmisison loss, Doors

Entrance doors, installed in an exterior wood-framed wall, were evaluated in the laboratory. The sound transmission loss properties of operable doors were determined as they affect the noise reduction of the exterior shell of a residence. Weather stripping improves the effectiveness of solid core doors, but the most improvement resulted from the installation of well-fitting storm doors, either aluminum or wood. The noise reduction property of the wall was not significantly reduced by doors equipped with well-fitting storm doors.

77-134

How to Accurately Predict the Sound Insulation of Partitions

R.E. Jones

U.S. Dept. of Agriculture, Madison, WI, S/V, Sound Vib., 10 (6), pp 14-17, 20-25 (June 1976) 15 figs, 32 refs

Key Words: Sound transmission loss, Walls

Two recent developments have provided a new look and fresh start to the prediction of transmission loss (*TL*) for partitions under lab and field conditions. One development is lab-field correlation studies as they relate to partition, flanking, and test environment factors. The other is further *developments in approximate TL theory for double panel* constructions. When these studies are combined into a coherent and integrated technology, considerable synergism occurs. Immediate benefits include identification of some acoustical myths and recognition of some lab and field data that are both higher and lower than some published data.

77-135

The Seismic Design of Reinforced Earth Walls

G.N. Richardson

Ph.D. Thesis, Univ. of California, 770 pp (1976) UM 76-21, 354

Key Words: Seismic design, Walls, Harmonic excitation, Random excitation

The dynamic response of reinforced earth walls to harmonic and random excitations was investigated. Three separate but complementary studies were performed: 1) harmonic base acceleration tests on model walls having a variety of reinforcement arrangements, 2) construction and dynamic testing of a conventional 20 foot high reinforced earth wall, and 3) limited dynamic testing of four additional commercial reinforced earth walls. The purpose of this research was to develop a seismic design procedure such that a reinforced earth wall can be designed to resist a given base motion within a specified allowable displacement.

77-136

Component Mode Analysis of Frames with Shear Walls

R.B. Barber and P.T. Blotter

Bechtel Corp., 50 Beale St., San Francisco, CA 94119, Computers and Struc., 6 (4/5), pp 397-403 (Aug/Oct 1976) 6 figs, 14 refs

Key Words: Walls, Frames, Component mode analysis, Finite element technique

A direct solution for the dynamic analysis of multistory frames with shear walls using finite element modeling techniques may exceed the size limitations of the computer and/or lead to errors in numerical calculations and long computer times. The application of component mode dynamic analysis techniques for the analysis of this type of structure was evaluated in this study. The accuracy of the results obtained, the comparative costs, and the advantages and disadvantages of the component mode method were investigated.

77-137

A Survey of the Optimal Design of Vibrating Structural Elements. Part II: Applications

N. Olhoff

Dept. of Solid Mech., The Technical Univ. of Denmark, Lyngby, Denmark, Shock and Vibration Digest, 8 (9), pp 3-10 (Sept 1976) 61 refs

Key Words: Structural elements, Vibrating structures, Minimum weight design, Variational methods

This paper surveys the optimal design of elastic structural elements undergoing free vibrations. The unified variational technique is used to minimize the material volume of a one- or two-dimensional continuous element with a specific natural frequency.

77-138

Prediction of the Nonlinear Dynamic Response of Structural Components Using Finite Elements

J. Donea, S. Giuliani and J.P. Halleux

Materials Div., Euratom J.R.C., 1-21020 Ispra (Varese), Italy, Nucl. Engr. Des., 37 (1), pp 95-114 (Apr 1976) 16 figs, 13 refs

Key Words: Structural members, Computer programs, Finite element technique

The finite element method has been chosen for the development of the computer programs EURDYN for the transient dynamic analysis of large-displacement, small-strain problems with material non-linearities. Since the EURDYN programs were conceived as tools for numerical investigations in the field of fast reactor safety, their main options were dictated by the type of structural behavior and by the nature of loading encountered in this context. Dynamic problems with small strains but arbitrarily large linear and angular displacements are frequent in fast-reactor engineering. A very efficient technique for dealing with such problems consists in formulating the equations of motion in terms of convected coordinates that rotate but do not deform with the elements. This method has been adopted in EURDYN.

77-139

A Summary of Methods for Computing the Degradation of Structural Elements Due to the Thermal and Thermal-Blast Effects of Nuclear Weapons

D.M. Wilson

Naval Surface Weapons Ctr., White Oak Lab., Silver Spring, MD, Rept. No. NSWC/WOL/TR-75-134, 97 pp (Mar 1976)

AD-A025 765/9GA

Key Words: Structural members, Nuclear explosion damage, Weapons effects

This report reviews and summarizes an existing large body of work on the effects of thermal radiation alone and thermal radiation combined with air blast effects on military structures or systems. All nuclear weapon phenomena were considered in order to find the ranges where thermal and thermal-blast effects are the most important. Methodology for computing the thermal and thermal-blast effects is summarized and references are given to provide the omitted details. The methods given were all used to compute effects in simple structural elements which are taken to be components of larger structures or systems. Graphs for thermal effects are presented which allow estimates of the resulting peak temperatures but no corresponding result exists for stresses due to thermal-blast effects. Instead, examples are given to illustrate general principles and computer programs are referenced for the solving of specific problems.

SYSTEMS

ABSORBER

77-140

Extension to Low Frequencies of the Formulae of Delany and Bazley for Absorbing Materials

F.P. Mechel

Grünzweig, Hartmann und Glasfaser AG, Ludwigshafen und Universität des Saarlandes, Labor Akustik, Saarbrücken, Germany, Acustica, 35 (3), pp 210-213 (June 1976) 2 figs, 5 refs

(In German)

Key Words: Absorbers (materials), Fiber composites

Empirical formulae published earlier for the characteristics of fibrous absorbing materials are corrected and extended to low frequencies. This extension is achieved on the basis of a correspondence with the Rayleigh absorption theory. The new formula will avoid errors of the original formulae at low frequencies.

77-141

Uniform Spinning Cable as a Vibration Absorber

O.L. Vance and J.H. Woodward

Univ. of Alabama in Birmingham, AL 35294, J. Acoust. Soc. Amer., 60 (3), pp 640-644 (Sept 1976) 4 figs, 6 refs

Key Words: Vibration absorbers, Cables, Disks

This paper presents an analysis of the free vibrations of a disk-cable system spinning freely about a fixed axis through the disk center. Secondly, it is shown how the cable can be used as a vibration absorber to reduce the effect of torsional disturbances on a rotating system.

77-142

Characteristics of the Dynamic Vibration Absorber with Elastically Supported Damper

D. Ardayfio

Univ. of Science and Technology, Kumasi, Ghana, West Africa, ASME Paper No. 76-DE-43

Key Words: Dynamic vibration absorption (equipment), Dampers, Elastic foundations

The elastically supported damper is incorporated into the auxiliary system in the design of dynamic vibration absorbers. Response curves are obtained and optimum design conditions are derived in terms of the variable parameters of the system. The results are compared with the conventional linear Frahm absorber and its modifications.

ACOUSTIC ISOLATION

(See Nos. 29, 133, 134, 230)

NOISE REDUCTION

(Also see Nos. 57, 60, 97, 99, 153, 154, 155, 158, 159, 176, 184, 189, 191, 199, 207, 216)

77-143

Acoustic Analysis of Mufflers for Engine Exhaust Systems

C.J. Young

Ph.D. Thesis, Purdue Univ., 226 pp (1973)

UM 76-20,258

Key Words: Mufflers, Engine noise, Finite element technique, Variational methods

A numerical technique based on the finite element method is developed for analyzing the performance of complex mufflers. The theories developed are the variational formulation of the acoustic field existing in the muffler and the finite element approximate solutions of the variational problems.

77-144

Scale Model Studies of the Effects of Wind on Acoustic Barrier Performance

R. DeJong and E. Stusnick

MIT Acoustics and Vibration Lab., Cambridge, MA 02139, Noise Control Engr., 6 (3), pp 101-108 (May-June 1976) 14 figs, 8 refs

Sponsored by the National Science Foundation

Key Words: Noise barriers, Sound transmission, Noise reduction, Model testing

This report is on experiments used to study scale modeling of the propagation of sound over barriers. These results show two effects of the wind on the performance of barriers. First, the barrier attenuation is increased for upwind propagation and decreased for downwind propagation. The fluctuations in the measured levels of the wind reduction were of the same order as the mean value.

77-145

Single Stage, Low Noise Advanced Technology Fan. Volume 3: Acoustic Design

S.B. Kazin and R.B. Mishler

Advanced Engrg. and Technology Programs Dept., General Electric Co., Evendale, OH, Rept. No. NASA-CR-134803; R76AEG259-Vol-3, 56 pp (Mar 1976)

N76-24238

Key Words: Fans, Ducts, Aircraft, Noise reduction

The acoustic design for a half-scale fan vehicle, which would have application on an advanced transport aircraft, is described.

ACTIVE ISOLATION

77-146

Application of the Aerodynamic Energy Concept to Flutter Suppression and Gust Alleviation by Use of Active Controls

E. Nissim, A. Caspi and I. Lottati

Technion-Israel Inst. of Technology, Rept. No.NASA-TN-D-8212; L-10738, 93 pp (June 1976)

N76-26585

Key Words: Active isolation, Flutter, Aircraft

The effects of active controls on flutter suppression and gust alleviation of the Arava twin turboprop STOL transport and the Westwind twinjet business transport are investigated.

77-147
Semiactive Control of Multimode Vibratory Systems using the ILSM Concept
D. Karnopp and R.R. Allen
Dept. of Mech. Engrg., Univ. of California, Davis, CA, J. Engr. Indus., Trans. ASME, 98 (3), pp 914-918 (Aug 1976) 8 figs, 12 refs

Key Words: Continuous parameter method, Mathematical models, Active isolation

The Identically Located Sensor and Manipulator concept involves deriving a control force from measurements of motion at the force generator mounting point. A semiactive force generator may be made from a damper whose force-velocity law can be varied in response to a signal. These two ideas are discussed and the advantages from combining the two ideas for controlling several normal modes for distributed parameter structures are presented. Computer simulation results comparing active, semiactive, and passive suspensions for a beam-like structure subjected to broadband noise excitation are given to illustrate the performance capability of each system.

AIRCRAFT

(Also see Nos. 24, 25, 26, 27, 50, 56, 57, 58, 62, 68, 74, 145, 191, 211, 219)

77-148
Ground Simulation of Flutter on Aircraft with High-Aspect-Ratio Wings
P. Rajagopal
European Space Agency, Paris, France, Rept. No. ESA-TT-263. 54 pp (Feb 1976)
(Engl. transl. from "Simulation au Sol du Flottement pour les Avions de Grand Allongement," ONERA, Paris, Rept. No. ONERA-NT-222, 1974)
N76-24216

Key Words: Aircraft, Aerodynamic excitation, Flutter, Simulation

A method is proposed for the simulation of the unsteady aerodynamic forces which act upon an aircraft in flight by means of an electromechanical apparatus.

77-149
Practical Design of Minimum-Weight Aircraft Structures for Strength and Flutter Requirements
K. Wilkinson, E. Lerner and R.F. Taylor
Grumman Aerospace Corp., Bethpage, NY, J. Aircraft, 13 (8), pp 614-624 (Aug 1976) 11 figs, 14 refs

Key Words: Aircraft, Flutter, Minimum weight design

Several methods for sizing the finite elements of an aircraft structural idealization to achieve minimum-weight design under combined strength and flutter-speed requirements are developed and evaluated. Two basic categories are considered: methods based on a combination of energy principles and optimality criteria; and procedures employing numerical-search techniques. Drawing upon the experience gained from studies of both of these basic methods, a resizing algorithm is developed that employs a uniform-flutter-velocity-derivative optimality criterion for flutter-critical elements and the fully-stressed-design criterion or strength-critical elements. The final result is a practical, automated approach for dealing with large-scale idealizations having both structural and mass-balance design variables.

77-150
Application of a Rand-Developed Nonlinear Programming Method to Flutter Optimization
Y.T. Phoa and F.H. Chi
Northrop Corp., Aircraft Div., Hawthorne, CA 90250, Computers and Struc., 6 (4/5), pp 305-312 (Aug/Oct 1976) 5 figs, 3 refs

Key Words: Aircraft wings, Flutter, Nonlinear programming, Computer programs

This paper describes the rationale applied to the development of a computer program for flutter optimization. The objective for the development effort was to arrive at a cost-effective structural optimization program for the preliminary design of fighter aircraft wings.

77-151
Analysis of Lateral Dynamic Stability of an Airplane with Deformable Control Systems
Z. Dzygadlo and E. Piotrowski
Polish Academy of Sciences, Inst. of Fundamental Technological Research, Warszawa, Poland, Journal of Technical Physics, 17 (2), pp 159-169 (1976) 8 refs

Key Words: Aircraft, Dynamic stability, Computer programs

The object of the study is to determine the lateral dynamic stability of an airplane with deformable aileron and rudder systems and moving weighted control organs.

77-152

Status of Methods for Aircraft State and Parameter Identification

P.G. Hamel

Deutsche Forschungs-und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany, In: AGARD Flight/Ground Testing Fac. Correlation, 16 pp (Apr 1976) (N76-25266)

N76-25282

Key Words: Aircraft, Helicopters, System identification, Parameter identification

The report of a meeting on aircraft system identification for flight test engineers and pilots, handling qualities and simulation experts, and aircraft and control system designers is presented.

77-153

Quieter Propellers for General Aviation: Present Position. Future Expectations

R. Hoffmann, G. Muehlbauer, et al

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 251-265 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 243-258, (N76-24243)

N76-24255

Key Words: Aircraft noise, Propeller noise, Noise reduction

The reduction of propeller noise of small executive and business aircraft is dealt with. Blade tips are the main noise source due to their circumferential speed. Noise reduction measures include shortening of the propeller to its repair minimum, and careful radiusing and profiling of the tip. The design of a variable pitch propeller with wooden blades combined with glass fiber plastics and metal is described. Future developments indicate large and low speed propellers, necessitating engines with gearboxes.

77-154

Aircraft Noise Reduction by Means of Acoustic Screening and Engine Controls

B. Gruenewald

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 149-178 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 145-172 (N76-24243)

N76-24252

Key Words: Aircraft noise, Noise reduction

With the arrangement of an engine above the wing it is possible to achieve sound screening for specific angles of radiation in relation to the ground. A calculation method for the determination of the ground noise level is described taking into account the screening effect of the wing.

77-155

Some Technical Problems of Quiet Aircraft Technology

W. Dittrich

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 94-121 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 89-117 (N76-24243)

N76-24249

Key Words: Aircraft noise, Noise reduction

Three problems peculiar to quiet aircraft technology were studied. A vertical take-off procedure which could lead to extremely low noise reverberation on the ground is presented. The relationships for the vortex noise from fans with subsonic air intake velocities were derived. Bypass fans with subsonic tip speeds were studied so that the vortex contribution investigated gains in importance. The application of atmospheric ion engines as quiet aero-engines is discussed.

77-156

Preliminary Measurements of Aircraft Airframe Noise with the NASA CV-990 Aircraft

K.C. White, P.L. Lasagna and T.W. Putnam

Ames Research Ctr., NASA, Moffett Field, CA, Rept. No. NASA-TM-X-73116; A-6506, 18 pp (Jan 1976)

N76-26145

Key Words: Aircraft noise, Airframes, Noise measurement

Flight tests were conducted in a CV-990 jet transport with engines at idle power to investigate aircraft airframe noise.

77-157

Assessment of Noise Exposure Produced by Variations in Landing Approach Procedures at San Jose Municipal Airport

J.F. Mills

Bolt Beranek and Newman, Inc., Cambridge, MA, Rept. No. BBN-2589, 55 pp (Aug 1973)

PB-253 368/5GA

Key Words: Noise generation, Aircraft noise, Landing, Airports

A series of noise measurements were performed at San Jose Municipal Airport in support of the EPA investigation of the use of aircraft operational procedures as means for noise control. These measurements were made to evaluate the effectiveness of different aircraft approach procedures, as used in normal practice by several different airlines, in reducing noise received on the ground in the vicinity of the airport.

77-158

Systematic Investigations in the Field of Acoustic Screening

H. Hoelscher

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 179-205 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 173-199 (N76-24243))

N76-24253

Key Words: Aircraft noise, Noise measurement

A series of tests was carried out on the screening effects of wings and tail surfaces on aircraft engine noise. The object was to test the applicability of prediction methods from optics on a surface having only one diffraction edge, which would conform as far as possible to the optimized condition. The effect of an edge radius such as applies to aerodynamic surfaces, and that of a sound absorbent coating on the noise screen on the source side, was also investigated; the applicability of results to real surfaces with two and three diffraction edges was established. Measurements were carried out at different distances from the surfaces on nonabsorbing and absorbent surfaces with one, two, and three straight diffraction edges and one radiused edge.

77-159

Investigation Into the Noise Propagation by Propeller Aircraft in General Aviation

E. Schmidt

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 207-249 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 201-241 (N76-24243))

N76-24254

Key Words: Aircraft noise, Propeller noise, Noise reduction, Noise measurement

A brief survey is given of the sources of noise in propeller-driven aircraft, their engines and propellers, together with the various mechanisms of noise generation. The results obtained in carrying out noise certification tests are reported.

77-160

Engine Noise

European Space Agency, Paris, France, Rept. No. ESA-TT-244; DLR-Mitt-74-21, 276 pp (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, 294 pp, Proc. of DGLR Tech. Comm. for Airbreathing Propulsion Systems Symp., Brunswick, 20-21 Feb 1974. Original German report avail. from *ZLDI, Munich*)

N76-24243

Key Words: Aircraft noise, Engine noise

Several aspects of aircraft noise are considered. They include jet noise, human reactions to aircraft noise in general, noise regulations, turbofan engine noise, compressor noise, wing and tail screening effects on engine noise, and propeller aircraft noise.

77-161

Aircraft Noise Limits

F.K. Franzmeyer

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 54-68 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 49-65 (N76-24243))

N76-24247

Key Words: Aircraft noise, Regulations

The effect of noise limit regulations upon the technical design of civil aircraft is discussed. The noise limits were laid down as a function of weight, because it was considered that a higher flying weight requires higher powered engines generating a higher noise level.

77-162
On the Calculation of Fan Noise
K. Heinig
European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 70-92 (Feb 1976)
(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 67-87 (N76-24243))
N76-24248

Key Words: Aircraft noise, Turbines, Fans

For high bypass ratio aircraft turbines, the noise generated by the unsteady aerodynamic forces and the propagation of the noise inside and outside the fan can be calculated by means of the heterogeneous wave equation.

77-163
Parachute Cluster Dynamic Analysis
D.F. Wolf and H.R. Spahr
Sandia Labs., Albuquerque, NM, Rept. No. SAND-75-5502; Conf-751127-1, 9 pp (1975)
Sponsored by ERDA
N76-24168

Key Words: Parachutes, Dynamic structural analysis, Mathematical models, Computer programs

A computer aided dynamic analysis of a parachute cluster is described which models the individual parachutes in the cluster and their combined effects on the motion of the attached forebody. The complex three dimensional motions of the forebody/parachute system are displayed using computer generated drawings of the bodies. Actual motion studies are accomplished using computer generated color movies. Simulated motion drawings and drop test photographs are presented for a system consisting of a cluster of three small parachutes attached to a large forebody and for a cluster of three large parachutes attached to a small forebody which experiences a rapid pitch motion. The necessity of modeling each parachute individually is illustrated for both systems.

BIOENGINEERING

(Also see Nos. 65, 164)

77-164
Mechanical Parameters of Hearing by Bone Conduction
S.M. Khanna, J. Tonndorf and J.E. Queller
Fowler Memorial Lab., Columbia Univ., New York, NY, J. Acoust. Soc. Amer., 60 (1), pp 139-154 (July 1976) 25 figs, 13 refs
Sponsored by the Deafness Research Foundation; National Inst. of Neurological Disease and Stroke

Key Words: Bones, Vibratory techniques, Vibrators, Diagnostics (biomechanics)

A new powerful, magnetostrictive bone conduction (BC) vibrator is described. At low output levels, it has a wide frequency range and for midfrequencies undistorted outputs reach up to 50g in terms of acceleration. BC thresholds and SL's (the latter determined by AC/BC cancellations) were measured with this vibrator.

BRIDGES

77-165
On Analytical Models for Two Types of Wind-Induced Oscillations of Suspension Bridges
D.S. Raila
Ph.D. Thesis, Princeton Univ., 227 pp (1975)
UM 76-20, 348

Key Words: Suspension bridges, Wind-induced excitation, Flutter, Resonant frequency, Vortex shedding, Mathematical models

Analytical models for both self-excited forces of flutter and structural resonance are investigated. Because of the complex nature of the interaction of the motion of a bridge with its aerodynamic wake, however, a certain amount of empirically obtained data is required to establish each model. The equations presented are supposed to hold for an ideal two-dimensional cross-section of suspension-bridge deck with two degrees of freedom.

BUILDING

(Also see Nos. 55, 229)

77-166

Prediction and Control of Vibrations in Buildings

E.E. Ungar, C.L. Dym, R.W. White

Bolt Beranek and Newman, Inc., Cambridge, MA, Shock and Vibration Digest, 8 (9), pp 13-24 (Sept 1976) 5 figs, 72 refs

Key Words: Buildings, Acoustic excitation, Vibration response, Vibration control

This paper is an overview of the engineering tools available for estimating building vibrations caused by external noise sources and unsteady air pressures, internal vibration sources associated with machinery and human activity, and external ground excitation associated with traffic and construction. Criteria for personnel, structures, and equipment are indicated. Methods for reducing building vibrations are discussed.

77-167

Concorde Noise-Induced Building Vibrations for Sully Plantation, Chantilly, VA

W.H. Mayes, H.F. Scholl, D.G. Stephens, B.G. Holliday, R. Deloach, H.K. Holmes, R.B. Lewis and J.W. Lynch

Langley Res. Ctr., NASA, Langley Station, VA, Rept. No. NASA-TM-X-73919; Rept-2630, 43 pp (June 1976)

N76-26949

Key Words: Buildings, Acoustic excitation, Vibration response, Aircraft noise

A study to assess the noise-induced building vibrations associated with Concorde operations is presented. The approach is to record the levels of induced vibrations and associated indoor/outdoor noise levels in selected homes, historic and other buildings near Dulles and Kennedy International Airports. Presented is a small, representative sample of data recorded at Sully Plantation, Chantilly, VA, during the period of May 20 through May 28, 1976. Recorded data provide relationships between the vibration levels of walls, floors, windows, and the noise associated with Concorde operations (2 landings and 3 takeoffs), other aircraft, nonaircraft sources, and normal household activities.

77-168

Vibration Tests of a 4-Story Reinforced Concrete Test Structure

C.K. Chen, R.M. Czarnecki and R.E. Scholl

Blume (John A.) and Associates, Research Div., San Francisco, CA, Rept. No. JAB-99-119, 108 pp (Jan 1976)

N76-26588

Key Words: Vibration tests, Buildings, Reinforced concrete

The results of a series of vibration tests conducted in 1974 to determine the dynamic response characteristics of a 4-story concrete test structure located at the Nevada Test Site are presented. The testing of this structure can be generally categorized as follows: nondestructive tests consisting of frequency sweep tests and frequency dwell tests, exciting four translational modes of vibration in the north-south (longitudinal) direction at low and intermediate force levels; a destructive test consisting of a frequency dwell test, exciting the lowest north-south translational mode at intermediate and high force levels, during which the structure exhibited inelastic response and suffered major structural damage; and a series of post-destructive tests using force levels similar to the nondestructive tests, conducted to investigate the response of the structure after it had experienced structural damage.

77-169

Active Control of Building Structures Subjected to Wind Loads

S. Sae-Ung and J.T.P. Yao

School of Civil Engrg., Purdue Univ., Lafayette, IN, Rept. No. CE-STR-75-2, 88 pp (Oct 1975)

PB-252 414/8GA

Key Words: Buildings, Multistory buildings, Wind-induced excitation, Monte Carlo method

The objective of this investigation is to study the feasibility of applying active control forces to building structures which are subjected to wind excitation. The criteria for human comfort and safety were chosen as a result of a literature review. A vibrational model of multistory building structures was studied through the use of the Monte Carlo method. Two different measures were used to indicate the energy requirement for active control. On the basis of limited number of sample functions, one feedback control law for comfort and another for safety were found to be feasible.

77-170

Noise and Vibrations in Residential Structures from Quarry Production Blasting

D.E. Sisking, V.J. Stachura and K.S. Radcliffe

Twin Cities Mining Research Center, Twin Cities, MI, Bureau of Mines Report of Investigations RI-8168, 17 pp (1976) 17 figs, 4 refs

Key Words: Buildings, Mines (excavations), Air blast, Blast response, Ground vibration, Vibration response, Noise generation

This Bureau of Mines report is concerned with environmental blast effects in six occupied residential structures. Airblast, ground, and structure vibrations were measured both inside and outside residences for seven quarry production blasts. Walls and floors responded to the blast noise and vibration by shaking at their own natural frequencies, often with greater peak particle velocities than the ground outside the structures or their foundations.

77-171

Evaluation of Seismic Safety of Buildings. Report No. 1. Frequency Content of Ground Motions During the 1971 San Fernando Earthquake

P. Arnold, E.H. Vanmarcke and G. Gazetas

Dept. of Civil Engrg., MIT, Cambridge, MA, Rept. No. MIT-CE-76-3, 78 pp (Jan 1976) (Also see PB-252 894-SET)

PB-252 895/8GA

Key Words: Buildings, Seismic response, Ground motion

Description of the site ground motion is an important step in the process of designing a structure subject to strong earthquake ground shaking. As a part of an overall effort to demonstrate the application of random vibration analysis to evaluate structural response to earthquake excitation, measurements made during the San Fernando, California earthquake of 1971 have been used to study extensively ground motion characteristics. The estimated power spectral density (PSD) function is used as the primary tool for studying ground motion characteristics, but comparisons based on peak acceleration, peak velocity, the ratio of peak values of velocity and acceleration, and selected response spectral values are also briefly reviewed. Observations are made on the variations in ground motion characteristics, followed by a tentative examination of the possible causes of these variations.

77-172

Evaluation of Seismic Safety of Buildings. Report No. 2. Simulated Earthquake Motions Compatible with Prescribed Response Spectra

D. Gasparini and E.H. Vanmarcke

Dept. of Civil Engrg., MIT, Cambridge, MA, Rept. No. MIT-CE-76-4, 102 pp (Jan 1976) (Also see PB-252 894-SET)

PB-252 896/6GA

Key Words: Buildings, Seismic response, Computerized simulation, Earthquake resistant structures, Computer programs

Alternate methodologies for generation of simulated earthquakes are briefly reviewed. The method of superposition of sine waves is discussed in detail. Theoretical relationships existing between the ground acceleration spectral density function and the response spectrum are derived. The program SIMQKE, which can generate response spectrum-compatible artificial motions, is listed and explained. Properties of resultant simulated motions are presented and their use in seismic design is discussed.

77-173

Evaluation of Seismic Safety of Buildings. Report No. 3. Comparison of Seismic Analysis Procedures for Elastic Multi-Degree Systems

E.H. Vanmarcke, J.M. Biggs, R. Frank, G. Gazetas and P. Arnold

Dept. of Civil Engrg., MIT, Cambridge, MA, Rept. No. MIT-CE-R76-5, 97 pp (Jan 1976) (Also see PB-252 894-SET)

PB-252 897/4GA

Key Words: Buildings, Seismic response, Computerized simulation, Earthquake resistant structures, Computer programs

This report compares different approaches to the dynamic analysis of multi-degree-of-freedom systems and, especially, evaluates the distribution of computed responses for the different approaches. Three methods of analysis are considered--exact time integration of real and artificial motions, a response spectrum approach, and a random vibrations approach--for several shear-type buildings covering a range of fundamental periods.

77-174

Evaluation of Seismic Safety of Buildings. Report No. 4. Variability of Inelastic Structural Response Due to Real and Artificial Ground Motions

R.A. Frank, S.A. Anagnostopoulos, J.M. Biggs and E.H. Vanmarcke

Dept. of Civil Engrg., MIT, Cambridge, MA, Rept. No. MIT-CE-R76-6, 98 pp (Jan 1976)(Also see PB-252 894-SET)

PB-252 898/2GA

Key Words: Buildings, Seismic response, Earthquake resistant structures, Computerized simulation, Computer programs

The variation of nonlinear dynamic structural response due to real and artificial ground motions is studied herein. Three four-degree-of-freedom systems were designed using Newmark's inelastic response spectrum, and statistics of ductility, accelerations and displacements were calculated. The effects of stiffness variation with height and change of the motion intensity are also examined.

77-175

A Study of the Uncertainties in the Fundamental Translational Periods and Damping Values for Real Buildings

R. Haviland, J.M. Biggs and E.H. Vanmarcke

Constructed Facilities Div., MIT, Cambridge, MA, Rept. No. R76-12, 119 pp (Feb 1976)

PB-253 188/7GA

Key Words: Buildings, Earthquake resistant structures, Seismic design

The first step in the seismic safety analysis of buildings is to determine the distribution of responses caused by uncertainty in design ground motion parameters. Further uncertainties due to expected period and damping values will alter the distribution of responses obtained for a model which is described by deterministic dynamic properties. Data is collected on the fundamental translational periods and damping values for real buildings, by means of a literature survey. Sources of uncertainty are identified and methods to statistically quantify this information are investigated. Finally, methodologies are suggested for incorporating the results into the safety analysis.

EARTH

(See No. 80)

HELICOPTERS

(Also see Nos. 25, 27, 59, 92, 152)

77-176

Possibilities and Problems of Helicopter Noise Reduction

V. Langenbucher and E. Laudien

Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn, West Germany, In: Contrib. to Helicopter Technol., pp 53-100 (Nov 11, 1975) refs. (N76-24209)

(In German)

N76-24211

Key Words: Helicopter noise, Rotary wings, Noise reduction

The generation mechanisms of helicopter noise radiation are discussed, and possibilities for reduction of the essential mechanical and aerodynamic noise sources are surveyed. External rotor noise can be reduced by a different layout of both rotors, leading to a weight and performance penalty.

77-177

Noise Phenomena with Helicopter Rotors and Possibilities of Noise Reduction

V. Langenbucher

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 266-292 (Feb 1976)

(Engl. transl. from "Triebwerkslaerm," DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 259-274 (N76-24243)

N76-24256

Key Words: Rotary wings, Helicopter rotors, Noise reduction

Possibilities of reducing helicopter rotor noise are discussed. Rotational noise is mainly determined by area loading, while rotor noise is determined by blade loading. The effects of area loading and circumferential speed, blade loading, and aerodynamic shape of the blade on noise generation were investigated, and requirements were developed for the rotor configuration. Experimental investigations of noise reduction of tail rotors are reported.

77-178

Structural Dynamics, Stability, and Control of Helicopters; Semiannual Technical Progress Report, 1 Nov 1975 - 31 May 1976

L. Meirovitch, L.G. Kraige and A.L. Hale

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. NASA-CR-148286; SAPR-3, 97 pp (June 1976)

N76-26191

Key Words: Helicopters, Dynamic synthesis

The dynamic synthesis of a helicopter is reported. The method of approach is a variation of the component mode synthesis in the sense that it regards the aircraft as an assemblage of interconnected substructures. The equations of motion are derived in general form by means of the Lagrangian formulation in conjunction with an orderly kinematical procedure that takes into account the superposition of motion of various substructures, thus circumventing constraint problems.

HUMAN

(Also see Nos. 26, 128, 205, 206, 212)

77-179

On the Hydrodynamics of the Inner Ear. Theoretical Part. A Mathematical Model

J.S.C. van Dijk

Institute of Phonetic Sciences, Univ. of Amsterdam, The Netherlands, Acustica, 35 (3), pp 190-201 (June 1976) 6 figs, 13 refs

Key Words: Ears, Hydrodynamic excitation, Mathematical models

In order to describe the hydrodynamics of the cochlea, a two-dimensional mathematical model has been constructed. The formulation of the problem leads to a classic type of boundary-value problem. From the general solution of the problem, three integral equations have been deduced to describe the dynamic behaviour of the cochlear partition. The first one is restricted to 'long-wave' phenomena. The second one is valid for 'short-wave' phenomena, whereas the third is independent of wave assumptions along the cochlear partition. Considerations of hydrodynamic similarity complete the conditions which are known from literature.

ISOLATION

(Also see Nos. 46, 201)

77-180

Efficient Optimal Design of Suspension Systems for Rotating Shafts

W.D. Pilkey, B.P. Wang and D. Vannoy

Dept. of Engrg. Science and Systems, Univ. of Virginia, Charlottesville, VA, J. Engr. Indus., Trans. ASME, 98 (3), pp 1026-1029 (Aug 1976) 6 figs, 10 refs

Sponsored by NASA; ARO

Key Words: Rotors, Shafts, Isolators, Optimum design

A new technique is proposed for the optimum design of support systems for rotating shafts. In this approach the conventional method of trial and error search for optimum parameter values for a prescribed design configuration has been replaced by an efficient two-stage procedure.

MECHANICAL

(Also see No. 204)

77-181

An Automatic Balancer Design for a Vertical-Axis Clothes Washing Machine

J. Vankirk and L. Burmeister

Whirlpool Corp., Benton Harbor, MI, ASME Paper No. 76-DE-24

Key Words: Washing machines, Balancing techniques

A practical design is presented for an automatic balancing system for a vertical-axis clothes washing machine. Applicable simple theory and typical unbalanced conditions for a domestic washing machine are given and the tests which verify the design's performance are described.

77-182

Fly-Shuttle Loom Noise Source Identification

W.L. Eckert, E.T. Booth, P.D. Emerson and J.R. Bailey

North Carolina State Univ., Raleigh, NC, ASME Paper No. 76-DE-39

Key Words: Textile looms, Noise source identification

Fly-shuttle loom noise is recognized as one of the most significant problems now confronting the textile industry. A two-phase experimental program has been conducted to identify sources of noise in a fly-shuttle loom. First, noise contributed by each major loom operation was identified by analyzing the sound-pressure waveforms radiated from the loom as it was assembled in stages. Results of this study should serve as a guideline for development of feasible engineering controls for fly-shuttle loom noise.

77-183

Mechanical Separation Phenomena in Picking Mechanisms of Fly-Shuttle Looms

F.D. Hart, B.M. Patel and J.R. Bailey
Center of Acoustical Studies, North Carolina State Univ., Raleigh, NC, J. Engr. Indus., Trans. ASME, 98 (3), pp 835-839 (Aug 1976) 9 figs, 11 refs
Sponsored by NIOSH

Key Words: Industrial facilities, Industrial noise, Textile looms, Mathematical models

Mechanical separation between cam and pick ball in fly-shuttle looms gives rise to impact and vibration which causes significant noise emission. Elimination of separation is analyzed using a mathematical model which simulates the dynamic response characteristics of the system. Parameters considered in the study include equivalent stiffness, mass, and damping of the system, amplitude of excitation, effect of preload provided by a retaining spring, and operating frequency. Combinations of system parameters and operating conditions which give rise to separation are predicted by examining the contact force developed between cam and cam-follower. Equations and graphs are presented that specify the preload required to eliminate separation as a function of the system parameters.

77-184

Spinning Frame Noise Sources

N.D. Stewart, P.D. Emerson and J.R. Bailey
Center of Acoustical Studies, North Carolina State Univ., Raleigh, NC, J. Engr. Indus., Trans. ASME, 98 (3), pp 840-844 (Aug 1976) 7 figs, 11 refs
Sponsored by NIOSH

Key Words: Industrial facilities, Industrial noise, Textile looms, Noise reduction

As part of a coordinated textile industry noise reduction program, a study of the sources of spinning frame noise has been conducted. Techniques of source modification and narrow-band frequency analysis were used. Several machines were studied.

METAL WORKING AND FORMING

77-185

Computer Design of a Multipurpose Minimum Vibration Face Milling Cutter

P. Doolan, F.A. Burney and S.M. Wu
Whirlpool Corp., Benton Harbor, MI 49022, Intl. J. Mach. Tool Des. Res., 16 (3), pp 187-192 (1976) 2 figs, 4 refs

Key Words: Machine tools, Noise reduction, Vibration control, Computer aided design

A weighted fractional usage design method is developed for obtaining the optimum blade spacings of a face milling cutter so as to reduce the noise and vibration levels. This method, which is executed on a digital computer, ensures low levels at every operating condition. Two illustrative examples are presented to demonstrate the multi-purpose nature of the cutter.

77-186

Dynamic Acceptance Tests for Horizontal Milling Machines Based on a Statistical Theory of Machine Tool Chatter

M.A. El Baradie, M.M. Sadek and S.A. Tobias
Dept. of Mech. Engrg., Univ. of Birmingham, Birmingham, Great Britain, J. Engr. Indus., Trans. ASME, 98 (3), pp 919-929 (Aug 1976) 11 figs, 9 refs

Key Words: Machine tools, Chatter, Statistical analysis

The dynamic characteristics of machine tools as well as the dynamic coefficients of the cutting process are statistical quantities which show scatter when determined in repeated tests. They can therefore be specified only in terms of mean values with confidence limits. The statistical theory of chatter developed in this paper deals with the scatter of dynamic data of the machine structure but assumes that the dynamic cutting coefficients have discreet values. This is used for analyzing two series of tests carried out on horizontal milling machines.

77-187

Platen Deceleration as a Mechanism of Noise Production in Impact Forming Machines

D.C. Hodgson
Dept. of Mech. Engrg., The Univ. of Birmingham, England, J. Mech. Engr. Sci., 18 (3), pp 126-130 (June 1976) 5 figs, 10 refs

Key Words: Metal working, Machine tools, Noise generation

The very rapid deceleration on impact of the platen (tup) in a drop forging machine is shown to be an important source of impulsive noise. An 'explicit' finite-difference method is used to calculate the sound pulse radiated by a platen in the form of a solid cylinder undergoing a decereration.

77-188

Computer Design of a Minimum Vibration Face Milling Cutter Using an Improved Cutting Force Model

P. Doolan, M.S. Phadke and S.M. Wu

Whirlpool Corp., Benton Harbor, MI, J. Engr. Indus., Trans. ASME, 98 (3), pp 807-810 (Aug 1976) 7 figs, 6 refs

Sponsored by National Science Foundation

Key Words: Cutting, Milling (machining), Mathematical models, Computer aided design

An improved cutting force model is integrated in the design of a minimum vibration face milling cutter. The cutting force of a blade is approximated by a rectangular pulse whose height is governed by the blade spacing. Specific examples of a special purpose and a general purpose cutter are given and their performances are evaluated.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see Nos. 95, 96, 162)

77-189

Noise Identification and Reduction for a Rotary Vane Compressor

W.R. Thornton

Ph.D. Thesis, Purdue Univ., 161 pp (1972)

UM 76-20, 257

Key Words: Compressors, Noise source identification, Noise reduction, Shells, Vibration isolation

The thesis problem is to investigate the noise sources and noise transmission paths of a rotary vane compressor and for the reduction of the noise radiated by the compressor. The compressor noise spectrum in the 0-3 K Hz frequency range was found to be essentially a line spectrum superimposed on low level broad band noise. The analysis of the spectrum indicated that the primary source of noise was generated by the pumping action of the compressor. It was determined that the mechanical transmission of noise between the pump-motor unit and the shell was more significant than the acoustical transmission of noise. These results were determined by measuring the acceleration of the pump-motor unit and by establishing a correlation between the acceleration spectrum and the sound spectrum of the shell.

77-190

A General Method for Simulating the Flow Dependent Nonlinear Vibrations of Compressor Reed Valves

J.P. Elson, W. Soedel and R. Cohen

Copeland Corp., Sidney, OH, J. Engr. Indus., Trans. ASME, 98 (3), pp 930-934 (Aug 1976) 6 figs, 8 refs

Key Words: Compressors, Valves, Beams, Mathematical models

A mathematical model is developed for the nonlinear vibrations of automatic reed valves in high-speed refrigeration compressors. Specifically considered are a general class of valves which wrap about curved backer plates. Two simple experiments are described which allow the nonlinearities of the valve system to be defined by a single nonlinear second order differential equation. Valve oscillation frequencies inside an operating compressor are predicted through a linearization of the valve equation. Comparisons with experiment are included.

77-191

Single Stage, Low Noise, Advanced Technology Fan. Volume 1: Aerodynamic Design

T.J. Sullivan, J.L. Younghans and D.R. Little

Advanced Engrg. and Technology Programs Dept., General Electric Co., Evendale, OH, Rept. No. NASA-CR-134801; R76AEG257-Vol-1, 145 pp (Mar 1976)

N76-24236

Key Words: Fans, Noise reduction, Aircraft noise

The aerodynamic design for a half-scale fan vehicle, which would have application on an advanced transport aircraft is described.

RAIL

77-192

A Computer Method for Calculating Dynamic Responses of Nonlinear Flexible Rail Vehicles

M.J. Healy

Wyle Laboratories, Colorado Springs, CO, ASME Paper No. 76-RT-5

Key Words: Interaction: rail-wheel, Railroad trains, Computer programs

This paper discusses a digital computer program which is capable of simulating rolling, heaving, pitching, swaying, and yawing motions of rail vehicles in response to track irregularities. Effects of several types of nonlinearities such as coulomb damping, wheel-rail separation, and nonlinear spring force-deflection characteristics, are taken into account. The method of superposition of normal modes is used to analyze the effects of car body flexibility. The program has been validated by comparison with experimental data. Several examples of the correlation with test data for the rock and roll problem are presented.

77-193

A Nonlinear Mathematical Model of the Dynamics of a Railroad Freight Car/Freight Element

T. Willis and K. Shum

Illinois Inst. of Technology, Chicago, IL., ASME Paper No. 76-DE-42

Key Words: Railroad cars, Freight cars, Mathematical models, Dynamic response

The dynamic response of a freight element, inside a typical freight box car under service conditions, is studied by a computer-model simulation technique. A 27-degree-of-freedom mathematical model has been developed to represent the freight car, truck and freight element, with the car body as a single rigid mass. The model has been validated against published data, and is more detailed than most previously published simulations, having additional characteristics.

REACTORS

(Also see No. 124)

77-194

Seismic Safety of Nuclear Power Plants

S. Hou

U.S. Nuclear Regulatory Commission, J. Environ. Sci., 76 (4), pp 26-29 (July/Aug 1976) 35 refs

Key Words: Nuclear power plants, Seismic design

Substanital conservatisms are introduced in each step that contributes to seismic resistant design for nuclear power plants. Such a buildup of conservatism is intended to provide adequate margin to accommodate two facts. There are possible uncertainties in determining the values of certain seismic parameters; and, there are possible inaccuracies in the use of certain simplified engineering practice.

77-195

Structural Analysis and Design of a Nuclear Power Plant Building for Aircraft Crash Effects

P. Degen, H. Furrer and J. Jemielewski

Motor-Columbus Consulting Engineers, Inc., CH-5401 Baden, Switzerland, Nucl. Engr. Des., 37 (2), pp 249-268 (May 1976) 27 figs, 8 refs

Key Words: Crash research (aircraft), Nuclear power reactors

The object of this investigation was to assess the effect of a large commercial airplane crashing perpendicularly on to the surface of a spherical reactor building dome. This investigation is related to a project currently in execution. Practical solutions of the postulated case, which vary in the degree of engineering effort used, are shown. Based on safety consideration the various solutions are discussed from the viewpoint of penetration, cracking and collapse modes of failure, where, primarily, the carrying capacity of the structure under an equivalent statical load is considered.

77-196

Wave Propagation Effects in Dynamic Loading

C. Albertini and M. Montagnanai

Applied Mechanics Div., C.C.R. EURATOM, I-21020 Ispra (Varese), Italy, Nucl. Engr. Des., 37 (1), pp 115-124 (Apr 1976) 10 figs, 9 refs

Key Words: Nuclear reactors, Shock wave propagation, Dynamic tests, Hopkinson bar technique

Dynamic tensile tests have been performed using the Hopkinson bar system on short test-pieces of AISI 304L and AISI 316L and various carbon steels, both at room and working temperatures and for varied strain rates.

77-197

A Survey of Numerical Methods and Computer Programs for Dynamic Structural Analysis

T. Belytschko

Dept. of Materials Engrg., Univ. of Illinois at Chicago, Chicago, IL 60680, Nucl, Engr. Des., 37 (1), pp 23-31 (Apr 1976) 3 figs, 26 refs

Key Words: Nuclear power plants, Nuclear reactors, Dynamic structural analysis, Computer programs

The safety analysis of nuclear reactors often involves the solution of non-linear, transient structure-continuum problems. Many general-purpose and special-purpose programs are available for this class of problems. The methods of integration found in these programs are described, particularly from the viewpoint of computational efficiency for the various classes of problems that are found in reactor safety analysis. The methods of time integration, in the usual manner, are subdivided into two categories; explicit and implicit. These methods are summarized along with their advantages and disadvantages and some recent results on their stability and accuracy.

77-198

Survey of Extreme Load Design Regulatory Agency Licensing Requirements for Nuclear Power Plants

J.D. Stevenson

School of Engineering, Solid Mechanics, Structures and Mechanical Design, Case Western Reserve Univ., Cleveland, OH 44106, Nucl. Engr. Des., 37 (1), pp 3-22 (Apr 1976) 21 refs

Key Words: Nuclear power plants, Seismic design, Shock resistant design, Blast resistant design, Earthquake resistant structures

Since 1965, when extreme load requirements began to be considered explicitly in nuclear power plant design, there has been a gradual divergence in requirements imposed by national regulatory agencies. However, nuclear plant safety is an international problem because of the potential international effects of any postulated plant failure. For this reason this paper has been prepared in an attempt to highlight the differences in national criteria currently used in the extreme load design of nuclear plant facilities. No attempt has been made to evaluate the relative merit of the criteria established by the various national regulatory agencies. This paper presents the results of a recent survey made of national atomic energy regulatory agencies and major nuclear steam supply design agencies, which requested a summary of current licensing criteria associated with earthquake, extreme wind (tornado), flood, airplane crash and accident (pipe break) loads applicable within the various national jurisdictions.

RECIPROCATING MACHINE

(Also see No. 143)

77-199

Possibilities of Noise Reduction for Fan Engines by Means of Controls

H. Dissen

European Space Agency, Paris, France, In: Engine Noise (ESA-TT-244), pp 138-148 (Feb 1976) (Engl. transl. from "Triebwerkslaerm", DGLR, Cologne Report DLR-Mitt-74-21, 1974, pp 133-144 (N76-24243)
N76-24251

Key Words: Engine noise, Jet noise, Fans, Noise reduction

A significant reduction of fan noise or jet noise can be achieved by varying the area of the primary and secondary propelling nozzles with constant engine thrust. For the engine with low bypass ratio, the fan noise reduction was calculated as being 4 dB max, and the jet noise reduction as approximately 5 dB max. As the bypass ratio increases, the fan noise reduction decreases while the jet noise reduction increases. It is not possible to reduce both noise components simultaneously by means of coupling the controls. The variation of the primary propelling nozzle has a significant effect on the generation noise; as the bypass ratio increases, variation of the secondary propelling nozzle becomes less effective in reducing noise.

77-200

A Mathematical Model of Helmholtz Resonator Type Gas Oscillation Discharges of Two-Cycle Engines

B.R.C. Mutyala

Ph.D. Thesis, Purdue Univ., 157 pp (1975)
UM 76-20, 488

Key Words: Engines, Noise generation, Helmholtz resonators, Mathematical models, Mufflers

The purpose of this investigation is to develop a mathematical model for simulation of the thermodynamically actuated acoustic behavior of a small two-cycle engine. For this study a three horsepower, single cylinder, two-cycle engine is used.

77-201

A Vibration Isolation Strategy for Small Engines with Unbalance at One-Third Operating Speed: The Wankel

J.C. Perso and F.A. Frohrib

Whirlpool Corp., Benton Harbor, MI, ASME Paper No. 76-DE-27

Key Words: Wankel engines, Vibration isolation

Methods for vibration isolation of a small unbalanced Wankel engine are considered using commercial isolator characteristics. A unique frequency component associated with unbalance in the Wankel engine occurs at one-third the operating speed. For certain designs, it may be appropriate to tune the isolators such that this frequency component resides between two clusters of natural frequencies. This technique permits the engine mounting to be selected sufficiently stiff to prevent the need for snubbers in the mounting system.

77-202

Noise Produced by the Interaction of Acoustic Waves and Entropy Waves with High-Speed Nozzle Flows

M.S. Bohn

Ph.D. Thesis, California Inst. of Technology, 221 pp (1976)

UM 76-20, 425

Key Words: Engines, Noise generation, Nozzles

Some aspects of the noise generated internally by a turbojet engine are considered analytically and experimentally. The emphasis is placed on the interaction of pressure fluctuations and entropy fluctuations, produced by the combustion process in the engine, with gradients in the mean flow through the turbine blades or the exhaust nozzle.

77-203

Structural Vibration of Diesel Engines

H.A. Fachbach and G.E. Thien

MTZ Motortech. Z., 37 (7/8), pp 269-274 (July/Aug 1976) 8 figs, 6 refs

(In German)

Key Words: Diesel engines, Vibration response, Noise generation

In the article research on the radiation of noise from combustion chambers to the outer walls of a water-cooled inline engine is described. It includes the material effect of cast iron and cast aluminum on the performance of the crank case, as well as the noise of crankshaft pulleys and the damping of vibration isolation elements in piping systems.

77-204

Estimation of Frequency Response in Acoustical Systems with Particular Application to Diesel Engine Noise

A.F. Seybert

Ph.D. Thesis, Purdue Univ., 273 pp (1975)

UM 76-20, 396

Key Words: Diesel engines, Noise generation, Combustion noise, Spectral analysis, Frequency response

The use of single and multiple-input linear models representing acoustical systems is discussed. A simple acoustical system, composed of electronic loudspeakers, is used to demonstrate the important aspects of spectral analysis and the estimation of frequency response functions. Theory is derived showing that bias errors are inherent in the estimation of the frequency response and coherence functions of acoustical systems.

ROAD

(Also see Nos. 31, 32, 99)

77-205

Noise Nuisance Caused by Road Traffic in Residential Areas: Part I

F.J. Langdon

Building Res. Station, Garston, Watford WD2 7JR, England, J. Sound Vib., 47 (2), pp 243-263 (July 22, 1976) 9 figs, 17 refs

Key Words: Traffic noise, Human response, Noise measurement

As part of a social survey dealing with the effects of road traffic noise, persons resident at sites in Greater London were interviewed. Noise levels were measured at the dwelling facades and the volume and composition of road traffic counted at each site.

77-206

Noise Nuisance Caused by Road Traffic in Residential Areas: Part II

F.J. Langdon

Building Res. Station, Garston, Watford WD2 7JR, England, J. Sound Vib., 47 (2), pp 265-282 (July 22, 1976) 5 figs, 8 refs

Key Words: Traffic noise, Human response, Noise measurement

As part of a survey dealing with the effects of road traffic noise, persons resident at sites in Greater London were interviewed, noise levels at the dwelling facades were measured and the volume and composition of the traffic at each site were counted.

77-207

Vehicle Noise Abatement During Development Work and in Series Production. Part 2

K. Kurz, K. Totos and M. Horvath

Automobiltech. Z., 78 (6), pp 291-294 (June 1976)
15 figs, 15 refs
(In German)

Key Words: Automobiles, Noise reduction, Experimental data

Noise was analyzed on seven buses during mass production.

77-208

Vehicle Barrier Systems

Transportation Research Board, Washington, D.C., Rept. No. TRB/TRR-566, ISBN-0-309-02476-5
PB-253 255/4GA

Key Words: Guardrails, Collision research (automotive), Highway bridges, Dynamic tests

This report on vehicle barrier interaction contains the following material: rollover-vaulting algorithm for simulating vehicle-barrier collision behavior; simplified criteria for evaluating flexible bridge rail performance; scale-model evaluation of frictional effects and redirection mechanisms for angle barrier impacts; development of a new collapsing-ring bridge rail system; dynamic tests of metal beam guardrail; pendulum tests using rigid and crushable bumpers; construction of frangible-tube, energy-absorbing bridge barrier system; and test and evaluation of a tire-sand inertia barrier.

77-209

Automobile Consumer Information Study Crash Test Program - Volume II - Technical Report

R.W. Carr

Dynamic Science Div., Ultrasystems, Inc., Phoenix, AZ, Rept. No. Dynamic Science-8268-75-189, DOT-HS-801 876, 190 pp (Apr 1976) (see also Summary rept. Vol. 1, PB-252 426)
PB-253 102/8GA

Key Words: Collision research (automotive), Crashworthiness, Crash tests

The objective of the vehicle crash test program was to develop test methodology for a series of vehicle rating tests and to produce a data base for use in determining crashworthiness and damage susceptibility ratings for contemporary automobiles.

77-210

Longitudinal Transient Behavior of a Rolling Tire: A Discretized Tire Tread Model

R.J. Vincent

Ph.D. Thesis, Cornell Univ., 228 pp (1976)
UM 76-21, 134

Key Words: Wheels, Tires, Longitudinal response, Digital simulation

A tire tread deflection model is developed to study the traction and braking behavior of a pneumatic tire. This model is similar to the University of Michigan Highway Safety Research Institute model in its basic approach but uses discrete tread elements to represent the tread layer and includes a consideration of the time history of tread deflection. This is necessary so that tread deflection in the transient case can be accurately modeled.

77-211

Pavement Response to Aircraft Dynamic Loads: Volume 2: Presentation and Analysis of Data

R.H. Ledbetter

Army Engineer Waterways Experiment Station, Vicksburg, MS, Rept. No. AD-A022806/4; S-75-11-Vol-2; FAA-RD-74-39-Vol-2, 213 pp (Sept 1975)
N76-25579

Key Words: Interaction: wheel-pavement, Runways, Pavements

Measurements of relative displacement, velocity, pressure, and temperatures were made in two pavement structures. Two phases of material behavior (elastic and inelastic) in both flexible and rigid pavement structures were identified. Each phase was treated independently for a full analysis of the static and dynamic load test results.

77-212

Traffic Noise Exposure and Annoyance Reactions

R. Rylander, S. Sorensen and A. Kajland

Dept. of Environmental Hygiene, Univ. of Gothenburg, Gothenburg, Sweden, J. Sound Vib., 47 (2), pp 237-242 (July 22, 1976) 3 figs, 9 refs

Key Words: Traffic noise, Human response

The relation between annoyance and exposure to traffic noise was studied in areas exposed to different levels of city traffic noise. A traditional social survey technique was used and the annoyance was evaluated as the percent very annoyed in population samples of about eighty persons.

77-213
The Noise of the Automotive Safety Air Cushion
R. Hickling
General Motors Res. Laboratories, Warren, MI 48090, Noise Control Engr., 6 (3), pp 110-121 (May-June 1976) 16 figs, 13 refs

Key Words: Air bags (safety restraint systems), Noise generation

Since passive restraint systems might still be required in all automobiles in this country, there is continuing interest in the use of the safety air cushion. The noise caused by the deployment of the cushion has been of concern since it was first envisioned. In this paper various aspects of safety air-cushion noise are presented.

77-214
A Simplified Technique for Prediction of Collapse Modes in Crash-Impacted Structural Systems
K.J. Saczalski and K.C. Park
Office of Naval Research, Arlington, VA, J. Engr. Indus., Trans. ASME, 98 (3), pp 902-908 (Aug 1976) 5 figs, 17 refs

Key Words: Collision research (automotive), Crashworthiness, Frames, Beams, Columns, Impact shock

A pseudostatistical technique utilizing linear system parameters for the determination of strain energy concentration patterns within shock-impacted structural system forms the basis for identifying the most probable regions and modes of collapse. The technique provides a simplified design-oriented tool for determining the energy management capabilities and crashworthiness of a given structure without the necessity of numerous, costly, destructive tests. Examples of the technique, as applied to a dynamically loaded beam-column and spatial frame, are given and compared qualitatively with experimental results.

77-215
Characteristics and Sources of Noise and Vibration and Their Control in Motor Cars
S.K. Jha
School of Automotive Studies, Cranfield Inst. of Technology, Cranfield, Bedford MK43 0AL, England, J. Sound Vib., 47 (4), pp 543-558 (1976) 18 figs, 9 refs

Key Words: Motor vehicle noise, Noise source identification

A detailed study of the characteristics of noise and vibration in a motor car is described. The predominant frequency regions in which noise levels are high are established.

77-216
Truck Noise IV-F: An Economic Study of Reducing the Exterior Noise Level on the International Harvester Quieted Truck
J.T. Shrader
Truck Div. Engrg., International Harvester Co., Fort Wayne, IN, Rept. No. DOT-TST-76-60, 86 pp (Mar 1976) (see also Rept. dated Apr 1975, PB-244 227)
PB-253 309/9GA

Key Words: Motor vehicle noise, Trucks, Noise reduction

This report discusses the economics of reducing the noise emissions of a typical, heavy duty, diesel truck used in line-haul operation. During this economic study, consideration was given to the change in the initial cost to the customer at the time of purchase, the change in maintenance cost due to parts and labor, the change in operating cost due to fuel consumption and the change in revenue earning capability of the truck.

77-217
A Survey of Truck Noise Levels and the Effect of Regulations
B.H. Sharp
Wyle Research, El Segundo, CA., Rept. No. WRC-74-8, 43 pp (Dec 1974)
PB-253 334/7GA

Key Words: Trucks, Motor vehicle noise, Regulations

A measurement survey was conducted to sample truck noise levels in different parts of the country under different operating conditions, the results of which would also indicate the effectiveness of certain existing state regulations.

ROTORS

77-218
A Modal Transient Rotordynamic Model for Dual-Rotor Jet Engine Systems
D.W. Childs
Mechanical Engrg. and Engrg. Management, Speed Scientific School, Univ. of Louisville, Louisville, KY, J. Engr. Indus., Trans. ASME, 98 (3), pp 876-882 (Aug 1976) 5 figs, 5 refs

Key Words: Mathematical models, Modal analysis, Lumped parameter method, Jet engines, Rotors

A transient modal simulation model is developed for a "typical" two-spool jet engine configuration, consisting of a low-speed rotor, a high-speed rotor, and the supporting case structure. The formulation cited permits bearing connections from a rotor to the support structure and between rotors. A conventional Jeffcott-Green flexible rotor formulation is used to model each rotor as a collection of rigid bodies connected by a massless elastic structure. The case structure is similarly modeled as a collection of axisymmetric elastically connected rigid bodies. The transient modal simulation model development is based on eigendata for the complete structural dynamics model (elastically coupled rotors and case structure) at zero running speed. The completed model readily accounts for gyroscopic effects, bearing damping and nonlinearities, structural modal damping, concentrated damping due to oil-film dampers, etc. The applicability and utility of the model is demonstrated by the simulation of a turbine-wheel blade loss.

77-219

Experimental Study of Transient Dynamics of a Flexible Rotor

D.H. Hibner and D.F. Buono

Pratt and Whitney Aircraft, East Hartford, CT, Rept. No. NASA-CR-2703; PWA-5333, 45 pp (June 1976) N76-26514

Key Words: Rotors, Transient response, Jet engines

The results of an experimental program to investigate the transient response of a flexible rotor are presented. The program consisted of a series of tests conducted on a rig with a rotor designed to operate above its first bending critical speed. The purpose of the tests was to obtain experimental data on the transient behavior of a flexible rotor under conditions simulating those which might occur in a jet aircraft engine. The scope of the program included tests to measure the response of both balanced and unbalanced rotors during steady-state operation, acceleration, deceleration, and simulated blade loss.

77-220

Acoustic and Aerodynamic Effects of Rotor Pitch Angles for a Variable Pitch, 6 Foot Diameter Fan Stage

R.P. Woodward and F.W. Glaser

Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-X-73418; E-8753, 20 pp (1976)

Key Words: Fans, Rotors, Noise generation

An externally driven, 1.2 pressure ratio full-scale fan stage with an adjustable pitch rotor was tested. Rotor pitch angles resulting in minimum sideline perceived noise levels are defined as a function of stage thrust. Thrust-corrected fan noise variations are examined for operation at constant thrust, rotor tip speed, and stage work coefficient.

77-221

Torquewhirl - A Theory to Explain Nonsynchronous Whirling Failures of Rotors with High Load Torque

J.M. Vance

Univ. of Florida, Gainesville, FL, ASME Paper No. 76-DE-29

Key Words: Rotors, Whirling, Failure analysis

This paper gives exact solutions to the nonlinear differential equations of motion for a rotor having both of these characteristics, and shows that high ratios of driving torque to damping can produce non-synchronous whirling with destructively large amplitudes. Solutions are given for two cases: viscous load torque and damping, and load torque and damping proportional to the second power of velocity (aerodynamic case). Criteria are given for avoiding the torquewhirl condition.

77-222

Experimental Evaluation of Multiplane-Multispeed Rotor Balancing Through Multiple Critical Speeds

J.M. Tessarzik, R.H. Badgley and D.P. Fleming

Machinery Dynamics Center, Mechanical Technology, Inc., Latham, NY, J. Engr. Indus., Trans. ASME, 98 (3), pp 988-998 (Aug 1976) 13 figs, 18 refs

Key Words: Rotors, Balancing techniques, Influence coefficient matrix, Experimental data

Experimental tests have been conducted to further demonstrate the ability of the Influence Coefficient Method to achieve precise balance of flexible rotors of virtually any design for operation through virtually any speed range. Four distinct practical aspects of flexible-rotor balancing investigated in the present work are reported herein.

77-223

A Linear Programming Approach for Balancing Flexible Rotors

R.M. Little and W.D. Pilkey

U.S. Res. and Dev. Administration Site Office, General Electric Co., Sunnyville, CA, J. Engr. Indus., Trans. ASME, 98 (3), pp 1030-1035 (Aug 1976) 5 figs, 6 refs

Sponsored by the Army Research Office

Key Words: Rotors, Balancing techniques, Linear programming

The feasibility of a new flexible rotor balancing method is demonstrated. Discrete "effective" unbalance components which produce the same observed response as the actual rotor unbalance are identified, and subsequently removed, using linear programming. The versatility of the new approach is demonstrated with example problems using a rotor model for which the response is obtained with a computer code.

77-224

Suppression of Rotor-Bearing System Vibrations Through Flexible Bearing Support Damping

J.M. Tessarzik, T. Chiang and R.H. Badgley

Mechanical Technology, Inc., Latham, NY, J. Engr. Indus., Trans. ASME, 98 (3), pp 1053-1061 (Aug 1976) 17 figs, 6 refs

Key Words: Rotor-bearing systems, Vibration dampers, Random excitation

A bearing damper, operating on the support flexure of a pivoted pad in a tilting-pad type gas-lubricated journal bearing, has been designed, built, and tested under externally applied random vibrations.

SHIP

77-225

Allowance for Shear Distortion and Rotatory Inertia of Ship Hulls

R.E.D. Bishop and W.G. Price

Dept. of Mechanical Engrg., Univ. College London, London WC1E7JE, England, J. Sound Vib., 47 (3), pp 303-311 (Aug 8, 1976) 1 fig, 8 refs

Key Words: Ship hulls, Beams, Transverse shear deformation effects, Rotatory inertia effects

The response of a ship to waves and to propeller excitation (as well as its distortion in still water) may be analyzed in modal form by using a linear theory. For symmetric responses the approach has been discussed in terms of a "hull girder" treated as a simple beam. The same is true of uncoupled bending in antisymmetric motion. Simple beam theory has also been adapted for use in "coupled bending and twisting" responses of hulls with large deck openings. The theory has not, hitherto, embodied an allowance for the effects of shear distortion or rotatory inertia.

SPACECRAFT

77-226

Computer Program System for Dynamic Simulation and Stability Analysis of Passive and Actively Controlled Spacecraft. Volume 1. Theory

C.S. Bodley, D.A. Devers and C.A. Park

Martin Marietta Corp., Denver, CO., Rept. No. NASA-CR-144758; MCR-75-17-Vol-1, 113 pp (Apr 1975) (see also Vol. 2, N76-25320; Vol. 3. N76-25321)

N76-25319

Key Words: Computer programs, Spacecraft

The dynamic system (spacecraft) is modeled as an assembly of rigid and/or flexible bodies not necessarily in a topological tree configuration. A theoretical development and associated digital computer program system is presented. The computer program system may be used to investigate total system dynamic characteristics including interaction effects between rigid and/or flexible bodies, control systems, and a wide range of environmental loadings.

77-227

Measurements of Acoustic Responses of Gaseous Propellant Injectors

B.A. Janardan, B.R. Daniel and B.T. Zinn

School of Aerospace Engrg., Georgia Inst. of Tech., Atlanta, GA 30332, J. Sound Vib., 47 (4), pp 559-569 (1976) 8 figs, 15 refs

Sponsored by NASA grant NGL 11-002-085

Key Words: Rockets, Combustion noise, Noise measurement

This paper is concerned with the experimental determination of the response factors of a variety of coaxial gaseous propellant rocket injectors. The injector response factors are obtained from injector admittance data measured under cold-flow conditions simulating those observed in rocket motors experiencing axial instability.

77-228

Vibration Detection of Component Operability

B.Baird

Boeing Aerospace Co., Houston, TX, ASME Paper No. 76-ENAs-18

Key Words: Spacecraft components, Diagnostic techniques

In order to prevent catastrophic failure and eliminate unnecessary periodic maintenance in the Space Shuttle Orbiter dynamic components, instrumentation for detecting incipient failure in these components is required. This study investigated the utilization of vibrational phenomena as one of the principal physical parameters on which to base the design of this instrumentation.

STRUCTURAL

(Also see Nos. 55, 171)

77-229

Wind and Seismic Effects - Proceedings of the Joint Panel Conference of the U.S. - Japan Cooperative Program in Natural Resources (6th) Held at National Bureau of Standards, Gaithersburg, MD on May 15-17, 1974

H.S. Lew

Inst. for Applied Tech., National Bureau of Standards, Washington, D.C., Rept. No. NBS-Special Pub 444, 465 pp (Apr 1976)

PB-252 683/8GA

Key Words: Structural response, Wind-induced excitation, Seismic response, Symposia

The Sixth Joint Meeting of the U.S. - Japan Panel on Wind and Seismic Effects was held in Washington, D.C., on May 15-17, 1974. The proceedings of the Joint Meeting include the opening remarks, the program, the formal resolutions, and the technical papers. The subject matter covered in the papers includes extreme winds in structural design; assessment and experimental techniques for measuring wind loads; dynamics of soil structures and ground response in earthquakes; structural response to wind and earthquakes and design criteria; disaster mitigation against natural hazards; and technological assistance to developing countries.

77-230

Response of Space Shuttle Insulation Panels to Acoustic Noise Pressure

R. Vaicaitis

Dept. of Civil Engrg. and Engrg. Mechanics, Columbia Univ., NY, Rept. No. NASA-CR-148201; FR-2, 48 pp (June 1976)

N76-25327

Key Words: Space stations, Acoustic insulation, Rayleigh-Ritz method

The response of reusable space shuttle insulation panels to random acoustic pressure fields are studied. The basic analytical approach in formulating the governing equations of motion uses a Rayleigh-Ritz technique. The input pressure field is modeled as a stationary Gaussian random process for which the cross-spectral density function is known empirically from experimental measurements. The response calculations are performed in both frequency and time domain.

USEFUL APPLICATION

77-231

Time-Frequency-Structures in the Attack Transients of Piano and Harpsichord Sounds - I

R.D. Weyer

Abteilung Musikalische Akustik, Musikwissenschaftliches Institut der Universität zu Köln, Acustica, 35 (4), pp 232-251 (1976) 25 figs, 51 refs

Key Words: Musical instruments, Vibration response

Using the example of attack transients of piano and harpsichord sounds, non-steady musical-acoustical vibration structures are studied in the time domain.

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JOURNAL OF APPLIED MECHANICS	J. Appl. Mech., Trans. ASME
JOURNAL OF BASIC ENGINEERING	J. Basic Engr., Trans. ASME
JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT, AND CONTROL	J. Dyn. Syst., Meas. and Control, Trans. ASME
JOURNAL OF ENGINEERING FOR INDUSTRY	J. Engr. Indus., Trans. ASME
JOURNAL OF ENGINEERING MATERIALS AND TECHNOLOGY	J. Engr. Matl. Tech. Trans. ASME
JOURNAL OF ENGINEERING FOR POWER	J. Engr. Power, Trans. ASME
JOURNAL OF FLUIDS ENGINEERING	J. Fluids Engr., Trans. ASME
JOURNAL OF HEAT TRANSFER	J. Heat Transfer, Trans. ASME
JOURNAL OF LUBRICATION TECHNOLOGY	*J. Lubric.* Tech., Trans. ASME

PUBLICATION AND ADDRESS	ABBREVIATION
TRANSACTIONS OF THE INSTITUTION ENGINEERS AND SHIPBUILDERS IN SCOTLAND W. R. STEWART (ED.) 183 BATH ST., 7 GLASGOW, C2, SCOTLAND	Trans. Instn. Engr. Shipbldg. Scotland
TRANSACTIONS OF THE INSTRUMENT SOCIETY OF AMERICA INSTRUMENT SOCIETY OF AMERICA, 400 STANDIX ST., PITTSBURGH, PA 15222	*Trans.* Instr. Soc. Amer.
TRANSACTIONS OF THE NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS NORTH EAST COAST INSTITUTION OF ENGINEERS, BOLBEC HALL, NEWCASTLE UPON TYNE 1, ENGLAND	Trans. North East Coast Inst. Engr. Shipbldg.
ULTRASONICS *ILIFFE SCIENCE AND TECHNOLOGY* PUBLICATIONS, INC., 300 E. 42ND ST., NEW YORK, N.Y. 10017	Ultrasonics
UNITED STATES CONGRESS ON APPLIED MECHANICS	U.S. Cong. Appl. Mech.
UNITED STATES NAVAL RESEARCH LABORATORIES, THE SHOCK AND VIBRATION BULLETIN SHOCK AND VIBRATION INFORMATION CENTER, NAVAL RESEARCH LAB., WASHINGTON, D.C. 20375	U.S. Naval Res. Lab., Shock Vib. Bull.
VDI FORSCHUNGSHEFT VEREIN DEUTSCHER INGENIEUR GMBH POSTFACH 1139, GRAF-RECKE STR. 84, 4 DUESSELDORF 1, GERMANY	VDI Fachungsheft
VDI ZEITSCHRIFT VERIN DUETSCHER INGENIEUR GMBH POSTFACH 1139, GRAF-RECKE STR. 84, 4 DUESSELDORF 1, GERMANY	VDI Z.
VEHICLE SYSTEMS DYNAMICS *SWETS AND ZEITLINGER N.V.* PUBLISHING DEPT. 347 B HERREWEG LISSE, NETHERLANDS	Vechicle *Syst. Dyn.*
WORLD CONGRESS ON APPLIED MECHANICS	World Cong. Appl. Mech.
ZEITSCHRIFT FUER ANGEWANDTE MATHMATIK UND MECHANIK AKADEMIE VERLAG GMBH 108 BERLIN, LEIPSIGER STR. 3-4, GERMANY	Z. Angew.
ZEITSCHRIFT FUER FLUGWISSENSCHAFTEN VEREIN DEUTSCHER INGENIEUR GMBH POSTFACH 1139, GRAF-RECKE STR. 84, 4 DUESSELDORF 1, GERMANY	Z. Flugwiss

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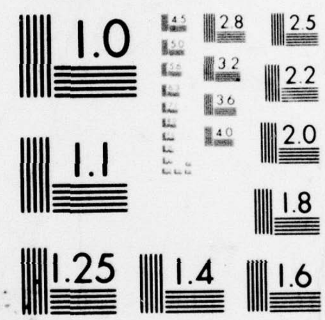

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MEETING	DATE	LOCATION	CONTACT
	1977 FEB		
Automotive Engineering Congress and Exposition (SAE Annual Meeting), SAE	28-4	Detroit, MI	SAE Hq.
Symposium on Biodynamic Models and Their Applications, CHABA of NAS-NRC	15-17	Dayton, OH	G. Thomas Collins, Univ. of Dayton, Dayton, OH 45469
	MAR		
NOISEXPO '77	14-17	Chicago, IL	NOISEXPO '77, 27101 E. Oviatt Rd, Bay Village, OH 44140 Tele. (216) 835-0101
Structures, Structural Dynamics and Materials Conference, AIAA	21-23	San Diego, CA	ASME or AIAA Hq.
15th Midwestern Mechanics Conference	23-25	Chicago, IL	Prof. T.C.T. Ting, Dept. of Materials Engrg., Univ. of Illinois at Chicago Circle, Box 4348, Chicago, IL 60680
Structural Dynamics Specialists Conference	24-25	San Diego, CA	AIAA Hq.
Gas Turbine Conference and Products Show, ASME	27-31	Philadelphia, PA	ASME Hq.
Joint Railroad Conference, IEEE/ASME	30-2	Washington, D.C.	IEEE Hq.
	APR		
American Power Conference, Ill. Inst. Tech.	18-20	Chicago, IL	R.A. Budenholzer, Dir. APC c/o IIT, 10 W. 35th St. Chicago, IL 60616
Design Engineering Conference and Show, ASME	18-21	New York, NY	ASME Hq.
Mini-Conference on Transportation	19-21	Ann Arbor, MI	Highway Safety Research Institute, The University of Michigan Ann Arbor, MI 48109 Tele. (313) 764-2168
Diesel and Gas Engine Power Conference and Exhibit, ASME	24-28	Dallas, TX	ASME Hq.
IES Annual Meeting	24-27	Los Angeles, CA	IES Hq.
9TH Space Simulation Conference IES-AIAA-ASTM-NASA	26-28	Los Angeles, CA	IES Hq.
International Conference - Tribology	April	Cambridge, MA	Lt. R.S. Miller, Code 211 Office of Naval Research, Ballston Tower No. 1, Arlington, VA 22117 Tele. 692-4421

CALENDAR

MEETING	DATE	LOCATION	CONTACT
	MAY		
23rd International Instrumentation Symposium	1-5	Las Vegas, NV	ISA Hq.
31st Annual Technical Conference, ASQC	16-18	Philadelphia, PA	R.W. Shearman, ASQC Hq.
93rd Meeting of the Acoustical Society of America	17-20	State College, PA	J.C. Johnson, Chairman, ASA
	JUNE		
Fuels and Lubricants Meeting, SAE	7-9	Tulsa, OK	SAE Hq.
Applied Mechanics Conference, ASME	14-16	New Haven, CT	ASME Hq.
Lubrication Symposium, ASME	June	St. Louis, MO	ASME Hq.
	SEPT		
Vibrations Conference, ASME	26-28	Chicago, IL	ASME Hq.